Popular Astronomy.

Vol. XXIX, No. 6 JUNE-JULY, 1921 Whole No. 286

SHERBURNE WESLEY BURNHAM.

By E. E. BARNARD.

Mr. Burnham was born in Thetford, Vermont, December 12, 1838. He was educated at the Thetford Academy. In 1857 or 1858 he went to New York. During the civil war he was stationed with the federal army in New Orleans, holding the position of shorthand reporter at headquarters. At this time he was a member of the firm of

"BURNHAM & BARTLETT
Short-hand Writers
No. 40 Camp street, New Orleans."

He came permanently to Chicago in 1866 where at first he was a member of the firm of

"ELY, BURNHAM & BARTLETT
Short-hand Writers
93 Washington Street, Chicago.
Official Reporters of the Courts of Chicago."

The above information is derived from two old business cards. He was Clerk of the U. S. Circuit Court in Chicago from 1892 to 1902.

It is always pleasing to know how a person became interested in astronomy. How Mr. Burnham became interested is told in an article by Professor John Frazer in the Century Magazine.

> "It was not until he had grown up and adopted stenography as a profession that Mr. Burnham had his attention directed to astronomy, and in a way sufficiently curious to warrant recital. During the civil war Mr. Burnham was stationed with the army in New Orleans, holding the position of shorthand reporter at headquarters. One afternoon as he was strolling along the street his eye was attracted by the notice of a book auction. He entered as the auctioneer was crying Burritt's "Geography of the Heavens"—the well-known work by a brother of the more famous Elihu Burritt. The subject was one in which Mr. Burnham had at that time no special interest, but he bid for the book, which was knocked down to him. On examining it he found it contained charts of the sidereal heavens. In these he soon became interested, and took advantage of the first clear night to study the heavens for himself, and to trace out the various constellations and

> principal stars described in Mr. Burritt's charts. Further study of the work served to deepen his interest, and he bought a small, cheap telescope. This, after some time and before leaving New Orleans, he exchanged for a better instrument, which he took with him to Chicago, somewhere about the year 1886. . . . . Up to this time he had not read much about astronomy, and it was the coming into the possession of the Rev. T. W. Webb's "Celestial Objects for Common Telescopes" that determined his future line of study and caused him to devote his entire energies to astronomical investigations during his leisure hours. Meanwhile he kept on reading the best books on physical and mathematical astronomy, and mastered the general features and principles of the science."

The views of the sky that he got with these small telescopes increased his interest in astronomy. In Chicago his home was at 36th Street and Vincennes Avenue, within a couple of blocks of the Dearborn Observatory, then new, which consisted of a great stone tower 90 feet high with a cylindrical "dome." This was attached to the old University of Chicago building. In this tower was the large telescope with an object glass of 18½ inches diameter made by Alvan Clark. At the time it was made it was the largest telescope of the kind in the world.

The proximity of this great instrument inspired Mr. Burnham with a desire for a larger and better telescope than he possessed, one that, though not so large as the Dearborn glass, would at least be of some practical use. In 1869 when Clark was returning through Chicago from observing the total eclipse of the sun in August of that year, Mr. Burnham made arangements* to meet him in the Dearborn Observatory. After consultation with Clark he finally ordered a 6-inch telescope from him for which he paid eight hundred dollars, the only stipulation being that the glass should be the best they could make.

Thus almost in the shadow of the largest refracting telescope in the world he started out with his modest equipment, which, by the work that he did with it, soon threw a shadow over the greater telescope and ultimately led to his use of the larger instrument—but of this later. It was here that with his keen eye and eminent industry, he discovered with his 6-inch Clark telescope over four hundred double stars, some of which were difficult objects with the largest telescopes. It is not at all improbable that the great fame of the Clarks had its beginning in Mr. Burnham's work with the 6-inch, though Dawes seems to have been the first to call attention to the remarkable defining power of the Clark lenses. In the hands of Mr. Burnham the 6-inch certainly immensely increased their reputation for good work, for the severest test of any object-glass is a close and difficult double star, and these were what he was dealing with.

Though equatorially mounted, the 6-inch at first had no driving clock. Mr. Burnham's ingenuity, however, soon overcame this diffi-

*According to Fraser.

culty. Around the polar axis he wound a cord on the end of which was a heavy weight resting in a receptacle filled with sand that ran out through an aperture in the bottom. When this was properly regulated his telescope would follow the stars. It was in these days that he was in correspondence with such men as Otto Struve, Dembowski, Schiaparelli, Flammarion, Webb and others prominent in the work he had chosen in astromony—the observation of double stars. Baron Dembowski (a Polish astronomer, then living in Italy) was the first to show a sympathetic interest in Mr. Burnham's work. He devoted much of his time to measuring the new Burnham stars before Mr. Burnham had the means for accurate measurement. This interest and encouragement was never forgotten and his high appreciation of it is shown in the dedication of the general catalogue of his own double stars, 1290 in number, (General Catalogue of Double Stars. Publications of the Yerkes Observatory. Vol. I) to Baron Dembowski in these almost pathetic words:

TO THE MEMORY OF
BARON DEMBOWSKI
THE DISTINGUISHED DOUBLE STAR OBSERVER, THE FIRST TO UNDERTAKE
THE SYSTEMATIC MEASUREMENT OF THESE STARS, AND WHOSE
SYSTEMATIC MEASUREMENT OF THESE STARS, AND WHOSE
KINDLY CRITICISM AND GENIAL ENTHUSIASM WERE
TO THE WRITER ALWAYS AN INSPIRATION
THIS VOLUME
IS GRATEFULLY INSCRIBED.

In Mr. Burnham's early work in astronomy he observed at night for the pure love of it. His days were busily spent in the courts of Chicago. Many of the men he worked with, it is said, knew nothing of the respect and honor that had come to him from the work of those sleepless nights, and when they would perhaps see something in the papers about Burnham the famous astronomer, it was difficult for them to connect this with the quiet man they had been in daily contact with for so many years.

His increasing reputation soon secured for him the use of the then great Dearborn telescope. He soon made that instrument famous. But singularly enough trouble arose here, perhaps from the very fact that he did make it famous, for after a while he was debarred from its use and the doors of the observatory were locked against him. It was not until a popular agitation arose over this treatment of so skillful an observer that its use was restored to him. Here, later, and under happier conditions, in conjunction with the new director, Professor G. W. Hough, he resumed his observations of double stars. Between these two men there existed a genial friendship.

No man perhaps ever worked with a more varied assortment of

telescopes than he. There were his first two small telescopes with which he began his examination of the heavens. Then his 6-inch Clark glass (which is now at the Washburn Observatory, Madison, Wisconsin), the 9.4-inch at Dartmouth, the 12-inch at the Lick Observatory, the 15-inch at Madison, the 16-inch of the Warner Observatory, Rochester, New York (now at Mount Lowe, California), the 18½-inch of the Dearborn Observatory (now at the new Dearborn Observatory, Evanston, Illinois), the 23-inch at Princeton, the 26-inch at Washington, the 36-inch at the Lick Observatory, and the 40-inch telescope at the Yerkes Observatory. What a proud array of telescopes which owe much of their reputation to this one man! These, with the exception of the first small ones, were all Clark glasses and had the same stamp of excellence. The reflecting telescope never seemed to appeal to him. Indeed, I think for visual work observers in general do not like this class of instrument, nevertheless for certain visual work it is probably superior to the refractor, and for photography it is supreme.

In 1879 he was selected by the Lick Trust, whose president was Captain Richard S. Floyd, to investigate the suitability of Mount Hamilton for astronomical observations. Taking his 6-inch Clark telescope which now apparently had a driving clock, he went to the mountain on August 17, 1879, remaining until October 16. After these two months of observation he presented a valuable report to the Lick Trust showing why the proposed Lick Observatory should be placed there, though the site had already been definitely selected for the realization of Mr. Lick's bequest. During this stay on Mount Hamilton he discovered 42 new double stars with the 6-inch, some of which were difficult objects even in large telescopes. There were 13 with a distance of less than one second of arc, and several with distances as small as one-half second or less. He also measured a list of known double stars that showed the excellent atmospheric conditions prevailing on Mount Hamilton.

He again visited the mountain, to observe the transit of Mercury, November 7, 1881, with Captain Floyd and Professor Holden, afterwards director of the Lick Observatory. Mr. Burnham observed the transit with the 12-inch Clark equatorial, which was then mounted, although the rest of the observatory was not finished. During this stay he discovered and measured a number of new double stars with the 12-inch, as well as measuring a list of already known doubles.

In 1888 he again went to the mountain and remained a permanent member of the staff of the Lick Observatory until 1892 when he returned to Chicago. In 1889, with Professor Schaeberle, he was sent on an expedition, financed by Colonel Charles F. Crocker, to observe the total eclipse of the sun at Cayenne, French Guiana, on December 22 of that year. Their reports were printed in one of the smaller contributions from the Lick Observatory.

Mr. Burnham became a member of the staff of the Yerkes Observatory in 1897with the title of Professor of Practical Astronomy in the University of Chicago. He continued his work there until 1914, when through age and failing health he retired and became Professor emeritus.

His contributions to the literature of double-star astronomy have been very great. They were mainly printed in the *Monthly Notices* of the Royal Astronomical Society of England, and the *Astronomische Nachrichten* of Kiel, Germany. A considerable portion of Volume I of the Publications of the Lick Observatory contains his early work with his celebrated 6-inch at Mount Hamilton before the Lick Observatory really existed, as well as his report to the Lick Trust on the suitability of Mount Hamilton for astronomical observations. Volume II of the Lick Publications consists entirely of his measures of double stars and of planetary and other nebulae made during his connection with the Lick Observatory. While at the Yerkes Observatory he added greatly to his contributions to the *Astronomische Nachrichten*. Volume I of the Yerkes Observatory, already mentioned, was devoted to a catalogue of his own discoveries. He also contributed a large number of double-star observations to Volume II of the same observatory. Number 168 of the Publications of the Carnegie Institution consists of his measures of proper motion stars, a valuable contribution to this department of astronomy.

Mr. Burnham's great work, "A General Catalogue of Double Stars Within 121° of the North Pole," was published by the Carnegie Institution (being Publication No. 5) in 1906. This splendid work consists of two large quarto volumes, Part I and Part II. Part I contains the catalogue proper, consisting of 256 pages with an appendix of 18 additional pages. It, with the appendix, contains the positions and designations of 13,665 double stars. Part II, with 1086 pages, contains the notes on the individual stars of the catalogue and diagrams of the orbits of many of the most important of them. The compilation of this great work was a Herculean task for one man. It is of specially great importance for it contains Mr. Burnham's critical notes on the observations and the results obtained from them.

The discovery of new double stars in recent years, especially through the systematic search for these bodies by Aitken and Hussey, has added greatly to the number of known doubles. To preserve a record of these it has been necessary to continue Burnham's great catalogue by the addition of the new discoveries. Foreseeing this and being unable, from failing health, to continue the work himself he intrusted it to Eric Doolittle, who collected all the new double stars that were known up to his own untimely death, which left the work unfinished. Doolittle, before his death, expressed the desire that the work be continued by Aitken of the Lick Observatory, by whom it is now being finished.

Mr. Burnham was honored for his double-star work by the Royal

Astronomical Society of England, which bestowed its gold medal on him in 1894. The celebrated Lalande prize of the French Academy of Sciences was also awarded him in 1904. He was honored with membership in all the great astronomical and many other scientific societies. The degree of M. A. was conferred on him by Yale University in 1878, and that of Sc. D. by Northwestern University in 1915.

He can justly be called the father of double-star astronomy in this country, where for so many years he was essentially the only authority on the subject. His mantle has now deservedly fallen upon Aitken of the Lick Observatory.

The filar micrometer was greatly changed and improved by him. His system of illuminating the micrometer wires, which has been generally adopted, makes it possible to accurately measure any object that can be seen, no matter how faint it may be. An engraving showing this device attached to a micrometer may be found in the Publications of the Lick Observatory, Vol. I, p. 63.

It has been the custom of some double-star observers, such as the Struves, to use a Greek letter to indicate their names when attached to a double star. The letter Σ attached to the number of a double star means that the star was discovered by William Struve, while OΣ means that it was one of Otto Struve's stars. In this manner Mr. Burnham adopted the Greek β as a symbol for his discoveries. This letter attached to a double star means that it was discovered by him. Thus the star 9 Argus is known in double-star literature as β101. It is a remarkable binary system, the components of which revolve around each other in about 23 years. It was discovered by Mr. Burnham with the 6-inch Clark telescope about 1875. Over thirteen hundred stars bear this symbol.

The Century Magazine for June 1889 (Volume 38, pp. 300 to 307) prints a valuable article by Professor John Frazer, with a portrait and diagrams, which gives an interesting account of Mr. Burnham's life and work up to the time of its composition. A note states that Professor Frazer died before the article was printed, and that it was revised for the press by a friend of the author who had co-operated with him in the preparation of the original paper. It is possible that Mr. Burnham was this friend, and that he may have revised the article. If so its contents will be accurate.

I am giving only a very rough and incomplete sketch of Mr. Burnham's astronomical work, because that phase of his life will be dealt with by others more competent than I am to write about it. But, as there is always another side to such a life as his that is of interest, and which, though it does not necessarily have a direct bearing on his real life work, still has its value as showing something of the man himself, I have endeavored to give here a few side glimpses of him, depending mostly on the associations of the years 1888 to 1892 at

the Lick Observatory. In some cases they may seem trivial, but I have thought them worthy of record.

Somehow I have always pictured to myself the astronomers of whom I have heard but have not seen, and especially those with whom I have corresponded. These mental pictures almost always proved to be wrong when I finally met the man. I had thus formed in my mind's eye a picture of Mr. Burnham, of whom I had not even seen a photograph. This impression was that of a large, heavy-set man with a stern countenance—one you would not feel at home with. What gave me this impression I do not know. I was young then and knew little of people in general, and I had associated a great name in any calling with a bearishness of manner that would be intolerable. I had, therefore, when going to the Lick Observatory, dreaded this meeting with him.

The first time I saw Mr. Burnham was in the fall of 1888 upon his arrival at the Lick Observatory from San Jose. He was covered with dust from the long stage ride. I recollect well his light blue eyes and cordial greeting. Instead of the large, austere man I had expected here was a thin, rather small man, one of the gentlest and kindest of men—more human than any man I had ever met. All fear that I had felt vanished when I came to know him and only love for him could take its place. He was then in the prime of life.

Mr. Burnham was of a slight, wiry build, tough as iron, with not an ounce of surplus flesh. This enabled him to stand great fatigue in his tramps through the mountains. During his residence in California he wore a rather drooping mustache, though otherwise clean shaved, but from some time after his return to Chicago his entire face was always closely shaven. This final absence of a mustache was a very great improvement for it showed his face, which was a noble one, to a greater advantage. To hide any part of it was unfortunate. It is curious how the presence or absence of a mustache may change one's opinion of a man's nature. Mr. Burnham's face, smooth shaven, was the one that best expressed his character to me. There was sometimes in it a suggestion of the face of Lincoln. The wonderful strength of his features was never more apparent than when he lay in the stillness of death. It seemed such a sad thing that no death mask was made of his face (always so remarkable and perhaps never so much so as in death) to preserve for future astronomers the features of one so loved by those who knew him best. A few months previous to his death his face was fuller and more rounded out but this seemed to be due to his sickness and had all disappeared when for the last time we looked upon him. It was then the face of the man we always loved—the true Burnham face.

Mr. Burnham was gifted with a very keen wit which was always ready for any event. He never failed to see the humorous side of things and to make a turn that would meet any emergency. He was generous to a fault; his hand was open to all who were in need. He

was always dressed very plainly and seemed to care very little for the changing modes and fashions of the day. He was a lover of Dickens and sometimes, when the humor seized him, liked to refer to Mr. Pecksniff or Mrs. Sairy Gamp. I do not recall that he had any special taste for poetry—perhaps it was not matter-of-fact enough for him. But he loved music and at his home he would often spend an hour or so with the "piano player." His taste was always for the higher class of music.

In the early days at Mount Hamilton, when conditions permitted, he worked through the entire night. Near midnight, when one's vitality always gets low, we would meet in his office or in mine and have a little lunch consisting of coffee and crackers and cheese, the coffee being made by Mr. Burnham over a lamp chimney by a little device that would hold a small pot. With this stimulant the rest of the night would go by in work on the measurement of double stars, etc. His rapidity in measuring was remarkable. This was partly due to the fact that he always made three settings of the wires before recording the readings, keeping them in his memory in the interval.

In recording his observations at the Lick Observatory he used a small bull's-eye lantern (there was no electricity then on the mountain) which usually besprinkled one with hot oil and was always disreputable looking. When not in actual use during the night it sometimes amused itself by tumbling down the steps of the observing chair. At the Yerkes Observatory in his later years he preferred the use of a small acetylene lamp belonging to his bicycle, which gave a rather powerful light; but this did not seem to annoy him because most of the objects he observed were bright.

Mr. Burnham and his children were great friends. While on Mount Hamilton the children would very often gather in the 36-inch dome and while he was observing they would sing and play on some musical instrument until late in the night. Thus the dome was often melodious with their childish voices.

He loved nature very much and one of his greatest pleasures was a tramp in the rough country about Mount Hamilton. On these occasions he went lightly equipped, with perhaps only a cracker or two in his pocket for the whole day's journey. Thus, accompanied only by his dearly loved camera, he would spend the entire day roaming in the mountains to return at night with a "bag" of beautiful photographs of the splendid views he had found in his wanderings. He had a specially keen eye for the artistic and his photographs were almost always works of art as far as photography could make them.

The ranchers and others living in the mountains were his great friends. To drop in on them during his tramps and to have a social chat with them seemed to be one of his greatest pleasures. There was one of these men in particular that Mr. Burnham liked to visit. This was a man named Bennett, a hermit who lived alone in a small cabin in one of the canyons in the shadow of Mount Hamilton where he had

taken up some forty acres of government land which was rich in manzanita. This wood, which is a deep red color throughout, finishes as beautifully as mahogany. It grows on the slopes of the California canyons and on the crests of the mountain ridges. It is scarcely more than a mere bush—a part of the chaparral—and never attains to the dignity of a tree. It is difficult to find a straight piece large enough to finish for a walking cane. With a skill that was rare, and a taste that was truly artistic, Bennett made from this richly colored and difficult wood the most exquisite ornaments for souvenirs, such as straight and polished walking canes, miniature cups and saucers, vases, small easels for photographs, tea caddies, and even small pieces of furniture, such as a small table, etc. In the fashioning and polishing of these Bennett was a master. He was also a musician and loved to play old-time melodies on the guitar and banjo. This was just the sort of man that Mr. Burnham liked to meet and he frequently stopped at the hermit's place in his tramps for a talk and to listen to the music. Of course Bennett posed for Mr. Burnham's camera and frequent artistic photographs were thus made of the hermit and his surroundings.* Poor Bennett! Some time after we had left California some of the Lick Observatory people (I believe it was) who frequently went down near his cabin for picnics on the Santa Ysobel Creek and who always called on him, found him dead in his bed. There was much mystery about this man. All sorts of reports were abroad to account for his seclusion. One was that he was the son of an English painter and for some cause not known had left England. He was a man of middle age, of a very gentle nature and apparently educated.

During part of his stay at the Lick Observatory Mr. Burnham was the U. S. Postmaster. These people of the mountains came frequently to the observatory for their mail. They would invariably stop for a little visit with him, where they were always welcome. I recall one very aged man, who, it was darkly hinted, used to be a Mormon. In all probabality the poor old man could not have told a Mormon from a water-buffalo! He was lame and rode a very aged white horse, apparently as old as himself. It was said that he had been crippled in a fight in his younger days with a large grizzly bear to the west, at the base of Mount Hamilton some 2,000 feet below where the observatory was afterwards located. He and his old white horse were splendid subjects for Mr. Burnham's camera. Mr. Burnham loved to talk with these old men about their early experiences in the wild regions about Mount Hamilton and elsewhere.

From this humble class of men in whom he delighted let us turn to the other side. He had friends who loved him as dearly in such men as Judge Walter Q. Gresham of the U. S. Circuit Court and Secretary of State during Cleveland's second term, Judge Melville W. Fuller, Chief Justice of the U. S. Supreme Court, Judge Henry

*It is a sad commentary on his constantly photographing of other people that no really good photograph of Mr. Burnham could be found to illustrate this article.

W. Blodgett and Judge Thomas Drummond, both of the U. S. Court for the Northern District of Illinois, and others equally eminent in judicial and other positions. These men looked with veneration on the humble star-gazer and were fully able to appreciate his remarkable character.

There is a wonderful fascination about the canyons of California, nowhere more marked, perhaps, than at Mount Hamilton. In the heat of summer everything becomes parched and dry on the mountain for the want of rain, and one feels frequently a sense of oppression in the eternal dryness and dust. Under these conditions we often went down into canyons for relief, for a visit to these places, where spring seems never to cease, is, in the dry season, like a visit to fairy land. Here one finds the green foliage of trees, wild flowers and graceful ferns in abundance—among them the delicate maiden-hair fern. Through these canyons always runs a cool crystal stream, over whose rocky margins and steep banks are spread masses of velvety green moss. Here and there open spaces in the foliage overhead let the sun's rays sparkle on the water as it flows peacefully by or leaps over beautiful waterfalls into the deep silent pools below. Such scenes as these were eagerly sought by Mr. Burnham as subjects for his camera. The north slopes of the canyons high above the streams, are generally covered with dense chaparral, while the south sides are more or less free from it, the bare spaces being covered with wild oats. It was easy to descend these southern slopes, say into Sulphur Creek canyon, and one could take long running jumps of twenty feet or more in the soft soil and reach the bottom in about twenty minutes. That was the pleasure of it! But in climbing up the same slopes it sometimes took hours to return, for the wild oats and the soft soil made one slip back almost as fast as he came up. When the exhausted one finally reached the top he usually registered a vow never to descend into the canyon again. But always in a few days he was ready to go once more, for the call of the canyon was more than fascinating—it was irresistible.

I recall an experience that we had at the time of one of the presidential elections. The voting place was at Smith Creek, some two thousand feet below the summit. Mr. Burnham suggested that we go down and vote. A canvass of the situation showed that he would vote the straight Republican ticket and that I would vote the straight Democratic ticket. Notwithstanding that we would thus mutually cancel each other's vote he thought we should do our duty anyway and go and vote. It was a very short and easy journey down the slopes of Mount Hamilton to the hotel at Smith Creek, though it was seven miles by the stage road. But Mr. Burnham thought we should make a pleasure trip of it and suggested that we descend into Sulphur Creek canyon to the south of the observatory and wander through this canyon to the confluence of Sulphur Creek with Smith Creek and thence down Smith Creek to the voting place. It was quite a journey and, though delightful, was in some respects a difficult one for there were some

dangerous points to be negotiated. Nevertheless, after many stops to photograph beautiful spots and to climb around precipitous corners, we got there all right just as the polls were closing. While we were congratulating ourselves on the fact that we were in time we were notified that we could not vote, as neither of us had registered. We then turned around and began the tedious ascent of the mountain, feeling satisfied that we had at least done our duty and tried to save the country once more.

Another experience of ours in the mountains I will never forget. In October of 1888 Mr. Burnham wished to make a distant photograph of the Lick Observatory from the south. The only point from which this view could be made was from Mount Santa Ysobel, a mountain as high as Mount Hamilton and separated from it, to the south, by a canyon some two thousand feet deep, through which runs the small but beautiful stream called Sulphur Creek. To get this picture we decided to make an expedition to this mountain. We were to cross the canyon that afternoon and camp that night in an open and level space, free from chaparral, in a grove of trees near the summit of Ysobel, and near which we were told was a spring that would give us fresh water. So, in crossing, we took with us from Sulphur Creek only enough water to make coffee. The party consisted of four, none of whom had ever been to Ysobel before. The night was brilliant with a full moon and the grove was an ideal place to camp. We arrived just at dusk and startled a group of deer which were enjoying the delights of the beautiful spot. But they quickly disappeared when the janitor (who was one of the party) fired a couple of futile shots at them. In this romantic spot we enjoyed our supper to the fullest extent. Part of the supper consisted of ham which was rather salty. Soon after supper the ham set us to work to find the spring which we knew must be somewhere near. We sought for it in the moonlight but could not find it. That night we were pretty thirsty but we lay down and tried to forget it in sleep. It is difficult to forget things, even in sleep, when one is very thirsty!

The next morning our thirst was greatly increased and we sought eagerly for the spring, but could not find it. As Mr. Burnham wished to get an early view of the observatory from the summit of Ysobel we stopped the quest and hastened on. There had once been an ancient trail here but it was now so overgrown that it was easily lost and we were soon beating our way through the dense chaparral which rose nearly to our shoulders and with its jagged and thorny branches tore clothes and scratched flesh to a maddening extent. Mr. Burnham, with his camera held high above the chaparral, beat his way ahead and finally appeared on a high jutting rock from which he could see the lay of the land. From this point of vantage he directed us to the open spaces, which often occur in the chaparral, until we were free on the summit. Having secured his photographs, and as our thirst was now consuming us, we decided to make all haste to reach Smith Creek

where we could get water. The sun was beating down strongly upon us and we were perishing for a drop of water. More struggles through dense chaparral, which tore our clothes and retarded our progress; more stops for photographs. Sometimes we got tantalizing glimpses of bright water in Sulphur Creek far below us which only aggravated our thirst, but our destination was Smith Creek which had more water in it! After this experience I can better understand the horrors of shipwrecked sailors, dying of thirst with "water, water everywhere, nor any drop to drink". Mr. Burnham picked up acorns which were plentiful under the oak trees, advising us to chew them, as they alleviated his thirst, but I got no satisfaction out of them.

When finally at about five o'clock we reached Smith Creek we immersed our entire heads in the cool refreshing water. My mouth was so dry that my tongue rattled about in it. Mr. Burnham, who was also sadly in need of water, suffered less than the rest of us. Perhaps the acorns after all had helped him to withstand the terrible thirst. The clothing of one of the party was so badly torn that it would not do for him to be seen at the Smith Creek hotel, which was reached a little later. Mr. Burnham went on to the hotel while the torn and ragged one hid in the background until he returned with a paper of pins and fixed him up, after which the damaged one passed even the criticism of the stoppers at the hotel. That night we were all too exhausted to walk back up the mountain as we had intended to do, so we were glad to be taken up the seven miles in a common carryall or light wagon. After several days when we had recovered our spirits we spoke of it as a most memorable experience which we would not have missed for anything, and doubtless Mr. Burnham would have been willing to suggest to perishing, shipwrecked mariners, that by frequently picking up and chewing acorns they might check their burning thirst.

He was specially delightful at the little picnics which were frequent on the mountain, and always enjoyed building the camp fire and making the coffee on these occasions. He loved exercise and one of his favorite amusements was to pitch quoits, where horseshoes took the place of quoits. A level space on the west side of the main building where the stages stopped while their passengers went in the observatory to see the great telescope and other instruments was the pitching ground. Here Mr. Burnham and others had their game of horseshoes. He was very expert at this, as he was at all things he undertook. He was also an expert bowler, and as a rifle shot his reputation was high on Mount Hamilton, mainly from his previous visits there, especially in 1879 when he frequently shot a deer. In later days he went hunting only with his camera, for he adopted that more humane method of hunting. When he returned from these trips he was happier than if he had taken the life of some innocent creature.

Mr. Burnham loved dumb animals and he liked to photograph them. One of his best photographs was of a cat on the top of a board fence in the act of springing at a bird. This photograph was given a prize at a

photographic exhibition in London. One of the most interesting photographs of animals that he secured at Mount Hamilton was of a wild fox which he detected sitting on a stone on the north slope of the mountain just below the 12-inch dome and meditatively looking over into the canyon below. Crawling down the slope and hidden by the chaparral, he secured an excellent picture of it. This was one of his cherished photographs.

He greatly desired to make a photograph of a rattlesnake coiled, and in the act of striking. Late one afternoon one of the younger members of the observatory came running to him with the news that he had discovered a very large rattlesnake coiled in the grass near the roadside and ready to strike. Mr. Burnham hastily got his camera, but when he reached the spot he found that the informer, in his excitement for fear the snake would get away, had killed it. Mr. Burnham was deploring the loss of his only chance to photograph a real live rattlesnake when, upon examining it he found that it was not a rattler after all but a large gopher snake which is harmless and of great value to the ranchers for its destruction of gophers, which injure the crops and especially the young trees.

That Mr. Burnham had a tender heart is best shown, perhaps, by an incident that occurred shortly after the removal of his family to San Jose and before they came up to the mountain. In Chicago they had a large brindle dog which had grown old in the family. They had left him in good care in Chicago. Reports reached them that Hector, this old dog, was slowly grieving to death for them. When he heard this Mr. Burnham had Hector sent to San Jose by express. Here he passed the remainder of his days in ease and comfort in a glorious climate, from which it would, even for a dog, be a sad removal to be transported to some bright paradise in the future.

Mount Hamilton is celebrated for its lizards, all of which are perhaps harmless. Some of them are large and slender, like snakes on legs, and remarkably quick in their movements; others are small and though shy, are apparently more friendly. All of them are beautifully graceful, with long slender tails. From the cottages on the saddle to the large brick residence of the Director, higher up near the summit, was a plank walk with cleats on it to aid in walking up. This was often referred to as the "chicken walk", and lay partly loose on the broken surface of the slope with many hiding places beneath. It was a favorite place for lizards which sought it for shade and protection. Mr. Burnham and I often walked slowly up this plank trail and studied the lizards, some of which were so tame that one could almost put his hands on them without their exhibiting fear. One morning, while thus watching the beautiful creatures we saw one which had no tail. It was evidently freshly broken off close to the body. We had heard that such lizards, whose tails are rather brittle, sometimes lost them in escaping from an enemy, or for some other reason, and that when this occurred another tail grew to take its place. He suggested that we watch this

fellow and verify the statement. For several months we frequently saw this same lizard at the same place. In the course of time the tail had healed over and grown considerably but was short and rather stubby, lacking all the grace of the slender tail, which seems to be the chief glory of a lizard. Doubtless if our investigations had been carried far enough we should have seen the tail entirely renewed, but during that particular season it was only a little more than half grown.

Of course the 36-inch telescope came in frequently for being photographed. An amusing incident occurred one time when Mr. Burnham carefully posed the telescope for the most artistic representation. To get everything sharp and clear in making these pictures he always used a small stop and gave a very long exposure, usually of an hour or more. Having arranged everything for the photograph with the camera on the balcony, he started the exposure and went down to his office until it was finished. In the meantime some one, showing a visitor round, came into the large dome and got on the floor to show how the thing worked. He moved the telescope about and raised and lowered the floor and turned the dome, the usual program for the edification of visitors. When he got through he left everything in a different position from that in which he had found it. Finally Mr. Burnham came back on to the balcony, removed his plate-holder and went into his dark room, which was close to the dome, on nearly the same level with the balcony. Here he had rigged up an oscillator for very long development. At that time he believed in developing very slowly—an hour or more—with a very weak developer. The result of the above exposure was that when the finished negative was examined there was one pier but on it were several 36-inch telescopes and the floor and inside of the dome were in an awful mix-up.

San Jose is thirteen miles, in a direct line, west from Mount Hamilton and over four thousand feet below. At night, as seen from Mount Hamilton, the city with its many electric lights looked like a wide and bright star cluster. Often the crescent moon would be seen shining over it, making a very beautiful picture. This was an excellent subject for Mr. Burnham's camera. One of his photographs of it shows the crescent moon shining above the lights of the city. To make this picture he hid the moon with his hat until sufficient time had been given to show the lights and then, quickly removing his hat, gave an instantaneous exposure to impress the moon also on the plate. In those days there were comparatively few lights in San Jose and it did not then present so rich a "star cluster" as it does today.

Mr. Burnham had many friends among the amateur camera men of San Francisco, many of whom were photographers of a high type. He often went to San Francisco to be with them on some of their photographic excursions.

Singularly enough, though such a skillful photographer, he did not seem to care for celestial photography, and, with the exception of some excellent lunar photographs which he made with the 33-inch photo-

graphic combination of the Lick 36-inch refractor, he did not take any active part in astronomical photography. Perhaps this was because it did not then seem that it was likely to be of service in the field of double star work.

Apparently he had little interest in comets. He even expressed, in a friendly way, to a comet-seeker on several occasions, that the one great fear of his life was that sometime he might disgrace himself by accidently finding a comet! In his work he frequently ran upon new nebulae near some double star or while hunting for new double stars. Notwithstanding this expressed fear he always measured the nebula and went back to it again to see if it really after all was not a comet!

Mr. Burnham was always very cautious and did not readily enthuse on any subject. He was often very skeptical of certain results and theories, in which he was usually justified by later events. One time a list of very small nebulae, which he had found and which had been printed, attracted the attention of a foreign astronomer, who having platted the observations had called his attention to the fact that they all fell closely on the coils of a spiral. When asked what he thought of this, he took a pencil and closing his eyes jotted down some eighteen points at random. Then very carefully connecting the points by selection he traced out a beautiful spiral which fitted each of the points. "That," said he, "is what it means"or, in other words, it meant nothing. He often expressed doubt of the implied accuracy of certain work (as shown by the "probable errors", for which he had very little respect) such, for instance, as stellar parallaxes before the era of accurate photographic work. He would say, "I think the better way to solve that problem would be to guess at twice the distance, and divide by two, for by that means you would halve the probable error of the result." I do not know that this brilliant idea was original with Mr. Burnham, but it was greatly like him! No man is perfect and sometimes he was on the wrong side of the question but this was seldom the case.

After his return from California he lived for some years within a few hundred feet of the Illinois Central Railway where trains were almost constantly rushing past day and night with the rattle and uproar of a very busy line. How he managed to sleep there was a mystery to me, but he evidently slept soundly, for when he came to the Yerkes Observatory and the night was cloudy he complained that it was so quiet he could not sleep.

During his connection with the Yerkes Observatory he lived in Chicago with his family and came out at the week's end for a couple of nights observation each week. The distance he traveled from his home in Chicago on these trips would not be far from 160 miles for the round trip. During the seventeen years, therefore, that he observed regularly at the Yerkes Observatory he must have traveled over 140 thousand miles to make his observations, or over half way to the moon.

For many years while at the Yerkes Observatory he would take

long bicycle rides to neighboring towns, being "in the saddle", as it were, all day long. To go with him on these trips was strenuous work, and to the unsophisticated meant, perhaps, a lay-up of a day or so for repairs.

Chicago being between the east and the west, Mr. Burnham's office in the Monadnock Building was a stopping place for astronomers going either west or east. Most of them had time enough to stop and see him. He always welcomed them and if there was time took them to lunch at some modest little restaurant, generally Italian or Greek, where the luncheon hour was spent mostly in delightful conversation, for he was a splendid host on these occasions. Many of the older astronomers will recall the pleasure such meetings with him gave them.

In Chicago there was a certain club called the "Owls" which I think Mr. Burnham and his friends originated and which had no hard and fast rules or regulations or even dues. The word was passed around and on some night they would meet at one of Chicago's numerous restaurants. Here, besides the more solid enertainment of food, they would often discuss some topic of interest to them all, such as some phase of photography, for most of them owned their cameras. Sometimes these talks were illustrated with the lantern. Always there was a genial flow of wit and humor of a superior kind to occupy the time. One night in the early part of 1896 the members met at a photographic studio and the wonders of the X-ray were for the first time exhibited to them, to their great satisfaction, and the bones of a human hand shown on a photographic plate with wonderful distinctness.

Mr. Burnham was happily married to Mary Cleland in Chicago on March 24, 1868. From this union came three sons, Augustus, Raymond and Harold, and three daughters, Marion and Lida, who were twins, and Grace. Mrs. Burnham and all the children are living. One can only mention with the deepest respect the name of Mrs. Burnham. Certainly in the choosing of a mate Mr. Burnham was fortunate. Never was there a more devoted, home-loving and sympathetic wife! Not only was her sympathy and motherly love devoted to her own family, but it was extended to all whom she knew. A sweet, gentle, patient woman, whose heart overflowed with sympathy and kindness for all.

Mr. Burnham died in Chicago on March 11, 1921 at 5:30 A. M. He had been ill for a long time, but his end was hastened by a fall at his home in which his hip was broken. The funeral was held on March 14 at Oakwood Cemetery, Chicago. Many beautiful flowers were sent from the Yerkes Observatory and the Lick and the Mount Wilson Observatories. On March 11 the flags hung at half mast all day at the Yerkes Observatory in respect to his memory.

Thus has passed one of the most remarkable men, in many ways, this country ever produced.

YERKES OBSERVATORY, May, 1921.

PLATE XVI

PROFESSOR EINSTEIN AT YERKES OBSERVATORY.

POPULAR ASTRONOMY, No. 286.

PROFESSOR ALBERT EINSTEIN GAVE THREE PUBLIC LECTURES ON RELATIVITY AT THE UNIVERSITY OF CHICAGO ON THE AFTERNOONS OF MAY 3, 4 AND 5. HE SPENT THE DAY OF MAY 6 IN VISITING THE YERKES OBSERVATORY. THE PHOTOGRAPH OF THE VISITING PARTY AND STAFF OF THE OBSERVATORY, TAKEN ON THIS OCCASION, INCLUDES THE FOLLOWING PERSONS, FROM RIGHT TO LEFT:

GEORGE C. BLAKSLEE
GEORGE VAN BIESBROECK
MISS MARY R. CALVERT
MISS ESTHER L. SEARLES
OLIVER J. LEE
DR. S. GINSBERG
(London)
DR. A. PFLUEGER
(Professor of Physics at the University of Bonn)
PROFESSOR ALBERT EINSTEIN
of Berlin
EDWIN B. FROST
PROF. A. C. LUNN
(Department of Mathematics of University of Chicago)
MISS HARRIET M. PARSONS
PROF. A. J. DEMPSTER
(Department of Physics of University of Chicago)
EDWARD E. BARNARD
MRS. DOROTHY K. SULLIVAN
MRS. FLORENCE B. LEE
MISS DOROTHY W. BLOCK
MISS ELSIE E. JOHNSON
JOHN A. PARKHURST
MISS LELA D. CABLE
STORRS B. BARRETT

THE POSITION OF THE SUN'S AXIS.

By FREDERICK R. HONEY.

The apparent rotation of the sun on its axis in 27-1/4 days—the synodic period—proved by the alternate appearance of spots on its surface at one limb and their subsequent disappearance at the opposite limb, enables the astronomer to determine the position of the sun's equator relative to the ecliptic, and the actual period of the sun's rotation in 25-1/3 days. The difficulty in the determination is due to the sun not being a solid body, and the consequent variation in the motion of the spots at different latitudes. The average of a large number of observations gives the longitude of the ascending node of the sun's equator, and the angle which its plane forms with that of the ecliptic. Since the sun's axis is perpendicular to this plane, its apparent position relative to the ecliptic, and to the north and south line of the celestial sphere at any assigned date is a simple problem of descriptive geometry.

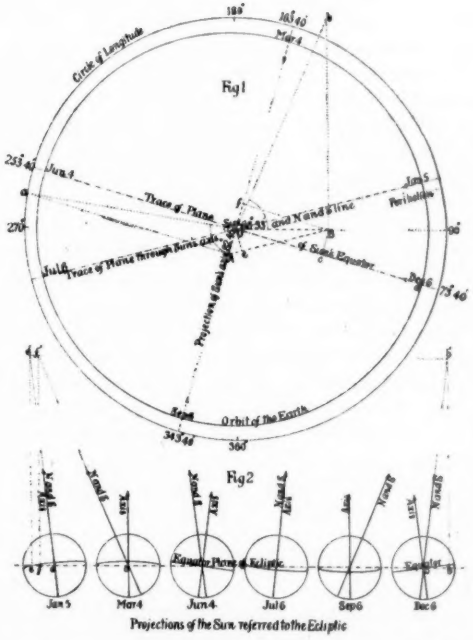

Fig. 1 is a plot of the earth's orbit. The longitude of the ascending

node of the sun's equator is 73° 40′, which gives the position of the trace of the plane of the equator, and which, passing through the sun, intersects the earth's orbit at opposite points. The earth reaches these positions on December 6 and June 4; and if the sun be projected on a plane which is perpendicular to the line of sight in the direction of the arrow, the equator, at each of these dates, takes the positions shown in Fig. 2. The eye of the observer in each case is in the plane of the equator, and it is therefore represented by a straight line which forms with the ecliptic an angle which is shown in its true value (—7° 15′). At these dates the spots appear to cross the sun's disc in straight lines parallel to the equator. At other dates the apparent paths are elliptical.

In Fig. 1 the projection of the axis on the plane of the ecliptic is perpendicular to the trace of the plane of the equator; and in Fig. 2 in each position it is perpendicular to the equator. In order to find the apparent position of the north and south line, construct the right angled triangle ObB (Fig. 1) making the angle bOB = 66° 33′ which is the inclination of the axis of the celestial sphere to the plane of the ecliptic, and which is directed to the pole of the heavens. OB is its projection on the plane of the ecliptic (long.=90°). Draw Bc perpendicular to Od, and in Fig. 2 lay off (Dec. 6) ob = cB (Fig. 1), and make bb′ perpendicular to the ecliptic equal to Bb; ob′ gives the apparent direction of the north and south line. The projections (June 4) are obtained by similar constructions. The equator, axis, and N and S line on June 4 and December 6 are symmetrical with respect to an axis which is perpendicular to the ecliptic and midway between these figures.

If a plane be passed through the axis and the north and south line, its trace, drawn through the sun, will intersect the orbit at opposite points which the earth reaches on January 5 and July 6. The trace of this plane is found by assuming points on the axis and on the N and S line at equal distances from the ecliptic. In Fig. 1 construct the right angled triangle OaA, making the angle AOa=82° 45′(=comp. 7° 15′); and make the perpendicular Aa = Bb. A and B are the projections of points in the plane equidistant from the ecliptic, and AB is therefore parallel to the ecliptic and to the trace of the required plane. Since the observer's eye is in this plane at each date, the axis and N and S line apparently coincide as shown in Fig. 2. To determine its inclination to the ecliptic draw Oe (Fig. 1) perpendicular to AB, and in Fig. 2 lay off (Jan. 5) oe = Oe. Draw ee′ perpendicular to the ecliptic = Bb (Fig. 1), and draw e′o which is the apparent position of both axis and N and S line. The construction is similar for July 6; and the projections of the equator, the axis, and the N and S line are symmetrical. It should be noted, however, that only that part of the equator which is visible is represented.

If a line be drawn through the sun perpendicular to the trace of the plane of the equator, it will intersect the orbit at opposite points which the earth reaches on March 4 and September 6. At these dates in Fig. 2 the sun's axis and the minor axis of the ellipse which represents

the equator are projected in the same line perpendicular to the ecliptic. To determine the N and S line, draw (Fig. 1) Bf perpendicular to the line of sight, and lay off (Fig. 2) March 4 o f = Bf (Fig. 1). Make ff′ perpendicular to the ecliptic equal to Bb; f′o is the apparent direction of the N and S line. As in the other projections the two figures March 4 and September 6 are symmetrical.

In order to realize the meaning of the constructions for each date, the reader should rotate Fig. 1 into a position where the earth is between him and the sun, and he is looking in the direction of the arrow. It should be noted that the sun's axis produced will pierce the celestial sphere at a point which is about midway between Vega (α Lyræ) and Polaris.

On account of the change of the earth's longitude each year, by a fraction of a degree, which is adjusted during leap year, there may be a change of one or more of the dates here given. For example, January 5 may read January 4.

THE PARALLACTIC MOTION OF THE STARS IN ZONES

By R. H. TUCKER.

The parallactic motion of a star may be defined as its apparent motion projected upon that radius of the celestial sphere which terminates at the point towards which the sun is moving—the apex of the solar motion. If the radial velocity of a star has been measured, the velocity along the radius directed to the star is transformed into the equivalent projection upon the radius directed to the apex. The determination of the direction and angular motion of the sun, as well as its velocity, all depend upon the assumption, thoroughly justified by the theory of probability, that the motions of the stars in space have all possible directions and a wide range of velocities, and that if a very large number of stars are included the mean of all their individual motions will be so close to zero that any residual of motion will be negligible. If a definite residual of motion be found in a discussion of observed motions, this residual represents then the change of position of the whole mass of stars with respect to the solar system. The motion of the sun in space would be of the amount indicated by this residual, and in the contrary direction.

The apparent motion of any star, as given by the measured changes in its position, or by the measure of its radial velocity, is thus made up of two effects. One is the actual motion of the star in space of three dimensions, and the other is due to the change in the position of the observer—the motion of the solar system. It is not possible to separate these two effects if neither one is known. The usual method of com-

puting the solar motion is to determine the direction and amount for each star as if the whole effect were due to the solar motion, and then sum up all the individual results.

A simple method of discussing the amount of parallactic motion, when we have a sufficiently large number of observed proper motions, is to combine these in zones of declination, and treat the zone results according to the trigonometrical formula for the transformation of coördinates. This process is equivalent to summing up the individual motions first, and then deriving the solar motion as a function of the mean result; thus reversing the usual process of deriving individual parallactic motions first, and summing up later.

A variety of values have been computed for the position of the solar apex, depending upon the character of the adopted apparent motions of the stars, their distribution and the numbers discussed in each investigation. These values will be found in publications devoted to practical astronomy, of popular as well as of technical character. The determinations of the right ascension have clustered about 270°, as a rule. Those of declination have varied rather widely. All of them give a northerly motion to the solar system, and the most recent and complete discussions place the apex between 30° and 40° north. For this discussion of proper motions in zones of stars the position of the apex adopted by the late Dr. Auwers, R. A. 270°, Decl. +40°, will be employed.

Let

A be the right ascension of the solar apex,
D be the declination of the solar apex,
α be the right ascension of a star,
δ be the declination of a star,
$\Delta\alpha$ and $\Delta\delta$ be the respective proper motions,
and c be the parallactic motion of a star.

Then

$$\Delta\alpha = F \sin \alpha \sec \delta - G \cos \alpha \sec \delta,$$
$$\Delta\delta = F \cos \alpha \sin \delta + G \sin \alpha \sin \delta - H \cos \delta.$$

The factors F, G and H depend upon the adopted position of the apex. Inversely, they may be derived by the above formulae, from observed proper motions.

$$F = c \cos D \cos A. \quad G = c \cos D \sin A. \quad H = c \sin D.$$

If A be adopted at 270°, for our present discussion, then F reduces to zero. It would be small with any value of the right ascension that has been derived. With the numerical values of G and H for A = 270°, and D = +40°, the expressions become

$$\Delta\alpha = \quad 0.77\, c \cos \alpha \sec \delta$$
$$\Delta\delta = -0.77\, c \sin \alpha \sin \delta - 0.64\, c \cos \delta$$

For any star a value of c can be derived from either coördinate of the observed proper motion, attributing these—for the moment—to the effect of parallactic motion. If the proper motions of the stars in a zone have been measured, and there are a sufficiently large number to give thorough and nearly uniform distribution in the zone, these simple expressions give values of c from the mean proper motions of the zone

of stars. The result represents the average parallactic effect for stars of the type selected. The type may be characterized by brightness, by average proper motion, or by both; as both serve as approximate criterions of relative distances.

In the computation of parallactic motion from a zone of stars the mean values of sin α and cos α are zero, and consequently the mean values of $\Delta\alpha$ and that of the first term in $\Delta\delta$ should be zero. In combinations of mean values for periods of six hours of right ascension they become periodic terms, with numerical factors of the same size in each period of six hours. The second term in $\Delta\delta$ is evidently a constant, for a zone of stars.

As an example, the summation of the proper motions of the recent catalogue of Nyren may be used. The list includes nearly six hundred accurately derived proper motions of stars to be employed as standards in the reduction of measures of photographs of the sky. The proper motions are new, in the sense that no thorough discussion had been previously made for any of these stars. They are consequently all of relatively small size, since large ones would have been detected earlier, in stars of this class, fifth to seventh magnitude. The average values are $\pm 0^s.003$ in right ascension, and $\pm 0''.03$ in declination, and the largest single values are $0^s.02$, and $0''.2$, annual proper motion in the two coördinates. I have combined the individual values in five zones:

0°	to	−30°	mean	−17°	from	262	stars
0°	"	+30°	"	+15°	"	186	"
+30°	"	+50°	"	+38°	"	84	"
+50°	"	+70°	"	+58°	"	37	"
+70°	"	+90°	"	+79°	"	26	"

The stars south of −30° are to be investigated for proper motion by Professor Hough. The combinations give the following expressions for the five separate zones. and the corresponding values of c from the periodic terms. Weights have been assigned according to the numbers of stars.

NYREN

						Wt.	c
$\Delta\alpha$ =	$-0^s.0005$	sec δ	$+0^s.0026$	cos α	sec δ	10	$+0^s.0034$
	−0.0004	"	+0.0020	"	"	7	+0.0026
	+0.0002	"	+0.0018	"	"	3	+0.0023
	−0.0002	"	+0.0014	"	"	2	+0.0018
	+0.0006	"	+0.0008	"	"	1	+0.0010
	Mean c by weights						+0.0028
	Equivalent to c =		+0″.042				

								c
$\Delta\delta$ =	−0″.013	+0″.000	sin α =	−0″.014	cos δ	+0″.000	sin α sin δ	+0″.022
	−0.013	−0.005	"	−0.013	"	−0.019	" "	+0.045
	−0.017	−0.017	"	−0.021	"	−0.028	" "	+0.069
	−0.012	−0.021	"	−0.023	"	−0.025	" "	+0.068
	−0.032	−0.022	"	−0.168	"	−0.022	" "	[+0.291]
	Mean c by weights							+0.040

The value of c from $\Delta\delta$ in the polar zone has been rejected, as there was evidently an excess of negative proper motions larger than the average size in the small number of stars. The two coördinates of proper motion

give weighted means nearly alike. There is a rather noticeable progression in the tabulated values, from each.

The proper motions of the stars employed in the zenith telescope observations at the International Latitude Stations have been discussed, and published anew in volume IV of the *Results*. There are 192 stars for the northern stations, with a mean declination +39°, and 192 for the southern stations, with mean declination —32°. The range of individual declinations is rather large, for treatment by zone methods, but there are not enough stars to give subdivisions of much weight. A necessary precaution in all summations is the rejection of extraordinary individual values, in forming the mean values. The size of the case to be rejected is partly a matter of judgment, depending upon the number of stars available. Those values that exceed five times the average value can properly be omitted, with a very conservative practice. The average of all the proper motion of the list of northern stars is close to ±0″.04. Omitting three individual motions that exceed 0″.2, the summation gives the following expression:

$$\Delta\delta = -0''.012 - 0''.011 \sin\alpha = -0''.015 \cos\delta - 0''.017 \sin\alpha \sin\delta,$$

and the derived value of c is +0″.046. For the southern stars there is one proper motion of 1″.56. The remaining stars have an average of ±0″.04. Omitting three individual values that exceed 0″.2, the summation gives the following expression:

$$\Delta\delta = -0''.016 + 0''.017 \sin\alpha = -0''.019 \cos\delta - 0''.032 \sin\alpha \sin\delta,$$

and the derived value of c is +0″.072. The two lists give the mean value $c = +0''.059$. The mean value from Nyren and the two zenith telescope lists, 0″.050, would represent the average annual parallactic motion for stars between fifth and seventh magnitude, with proper motions not exceeding 0″.2.

In 1914 some six hundred faint stars between +2° and —2° declination were observed here. They were selected from the A. G. catalogues of Albany and Nicolaief, and were of the average magnitude 8½. The comparison of the recent positions with those of the catalogues give the following systematic differences:

Lick — Albany	$\Delta\alpha = -0^s.040 + 0^s.033 \cos\alpha$,	$\Delta\delta = -0''.17$
Lick — Nicolaief	$\Delta\alpha = +0.009 + 0.028 \cos\alpha$,	$\Delta\delta = +0.15$

The mean systematic differences may be due to any one of a variety of causes, such as magnitude equation in transits, instrumental errors, and the adjustment of the fundamental places which was made in the interval. The periodic terms may possibly be the result of the parallactic motion in the long period intervening. The proper motions of these stars are so small that parallactic motion would be difficult to determine directly from the annual changes, while the parallactic effect, being cumulative, might be sensible in the long period. The Albany $\Delta\alpha$ would give the cumulative effect of $c = 0''.64$ in about 33 years, or +0″.019 yearly. The Nicolaief $\Delta\alpha$ would give $c = 0''.54$ in about 27 years, or +0″.020 yearly. The periodic terms in $\Delta\delta$ would be close to

zero, since they are functions of sin δ. The absence of periodic terms in the systematic differences in declinations is a confirmation of the hypothesis that the periodic terms may be due to the effect of parallactic motion, for these stars.

In 1917 a similar list of some eleven hundred stars was observed here, selected from the Harvard A. G. catalogue. The comparison of the places gives the following systematic differences, for mean declination +52°.5:

Lick — Harvard $\Delta\alpha = -0^s.027 + 0^s.033 \cos\alpha$
$-0.027 + 0.020 \cos\alpha \sec\delta$
$\Delta\delta = -0''.44 - 0''.53 \sin\alpha$
$-0.44 - 0.66 \sin\alpha \sin\delta$

The $\Delta\alpha$ gives $c = 0''.39$ in about 40 years, or $+0''.010$ yearly. The $\Delta\delta$ gives $c = 0''.87$, or $+0''.022$ yearly. The mean from the periodic terms of the two coördinates is $+0''.016$ yearly. From the three catalogues the value $+0''.018$ may be adopted as the average parallactic effect for stars of 8½ magnitude.

There were 150 stars employed here as standards, in the reduction of the observations of the Harvard catalogue stars. The fundamental system of Auwers was adopted for the places and proper motions. The average proper motions were $\pm 0^s.012$ in right ascension, and $\pm 0''.06$ in declination. Omitting from the summation eight cases where individual proper motions exceed five times the average, the combination gives the following expressions, for mean declination +52°.5:

$\Delta\alpha = +0^s.0004 \sec\delta + 0^s.0060 \cos\alpha \sec\delta$
$\Delta\delta = -0''.010 \quad -0''.047 \sin\alpha = -0''.010 \quad -0''.060 \sin\alpha \sin\delta$

For the fundamental system the mean differences between various epochs should be zero, and the above mean differences are accidental, from the fact that the fundamental list observed has not included a larger number of stars. The periodic term in $\Delta\alpha$ gives $c = +0''.119$. The periodic term in $\Delta\delta$ gives $c = +0''.079$. The mean of the values from both coördinates, $+0''.099$, may be taken as representing the parallactic effect for a list of stars between first and sixth magnitudes, in which no individual proper motion exceeds $0^s.06$, or $0''.5$ in right ascension, and $0''.3$ in declination. The average magnitude of these stars is 4¼.

If brightness be taken as an approximate criterion of distance, since the stars would then increase relatively 1.6 in distance for each increase of one unit of magnitude, the difference of about four units between the average magnitude of the fundamental stars and that of the zone stars should correspond to a ratio of six to one in the distances. The respective parallactic effects are nearly in this ratio, $0''.018$ to $0''.099$. The stars of the Nyren list and those of the zenith telescope lists are about two and a half magnitudes brighter than these zone stars, and the average distances should be in the ratio three to one, approximately confirmed by the computed values, $0''.018$ to $0''.050$.

The magnitude can only be adopted as an approximate criterion of distance in the discussion of large numbers of stars of the various types. If proper motion be adopted as a criterion, stars of all types are found to be well distributed in any volume of space. I have recently made the count of all stars with known individual proper motions of 0″.01 or greater, as published in the recent catalogue of Bossert, the last of his many contributions to this subject. There are 98 stars with proper motion as large as 1″, the adopted motion in this count being the resultant of the motions in the two coördinates, right ascension and declination. This is less than two per cent of the total number of stars listed, over 5,600. The average of all proper motions is close to 0″.20, and individual cases of 1″.0 can be properly omitted in the summation. Of these cases, fully one-third are of stars of eighth magnitude or fainter, and two-thirds are of sixth magnitude or fainter. Of the known proper motions of 0″.01 or greater fully one-quarter are of stars of eighth magnitude or fainter, and three-quarters are of sixth magnitude or fainter.

Omitting five cases of 1″ or greater, the stars to the third magnitude, mean 2.1, have an average proper motion of 0″.17. This is a fairly definite quantity, for those of proper motion less than 0″.01 would not sensibly affect the average. The proportion of stars having a known proper motion of 0″.01 to the whole number in the sky decreases as we go down the scale. It is 30 per cent from 5.0 to 5.9, 14 per cent from 6.0 to 6.9, 4 per cent from 7.0 to 7.9 and only one per cent for stars of eighth magnitude and fainter, the lowest limit included being about 9½.

With the percentages, and the observed average proper motions, it is possible to compute the average proper motions for all the stars of each grade. This computed value is given in the third column of the following table. The first column gives the mean magnitudes of the groups, as originally summed up. The second column gives the average known proper motions, when individual cases of 1″ have been omitted. The fourth column gives the computed average proper motion as a function of magnitude, allowing an increase in distance of 1.6 for each unit of magnitude, and adopting the observed value for magnitude 2.1.

AVERAGE PROPER MOTION.

Mag.	Observed	Computed	Ratio 1.6
2.1	0″.17	0″.17	0″.17
4.3	0.15	0.14	0.06
5.5	0.14	0.04	0.035
6.5	0.16	0.02	0.023
7.5	0.19	0.008	0.014
8.5	0.21	0.002	0.009

The average computed proper motion of the second group is much in excess of that given by the criterion of brightness. The similar averages in the last two groups are naturally too small, since there must be a very large number of small proper motions, of one or two hundredths of a second, as yet undetected in stars of those types. The

averages of the known proper motions for all the grades of brightness are nearly the same. With some additions from the catalogue of Nyren, there are about six thousand known proper motions of 0″.01 or greater. Further observations will undoubtedly add to the number for the faint stars, but the proper motions of all stars as bright as the sixth magnitude have been already determined within a small margin of uncertainty.

The parallactic motion is naturally closely related to the observed proper motion, for in computing the former from individual stars, or from groups of stars, we assume that the observed motion is due to the parallactic effect. From the annual proper motions of the brighter stars it is possible to derive an approximate value of the parallactic component, but for the faint stars the average of the annual values is evidently too small to carry out the computation with the necessary precision. The recourse to systematic changes in the positions of groups of faint stars, during a long period of time, is an expedient that appears to be justified.

The relation between the two classes of motion is well illustrated in the discussion of the parallactic effect from stars of exceptionally large individual proper motion, by Dr. O. Stumpe, published in the *Astr. Nach.* in 1890. He included only the stars of 0″.16 and upwards, and divided them into four groups. The limits of the groups, the averages, the magnitudes and the resulting values of c are given in the following table, for over 1000 stars.

		Stumpe.			
Group	Limits	Average	Av. Mag.	c	Stars
I	0″.16 to 0″.32	0″.23	6.0	0″.14	551
II	0.32 to 0.64	0.43	6.7	0.29	340
III	0.64 to 1.28	0.85	6.1	0.61	105
IV	1.28 and up	2.39	6.5	2.06	58

The ratio of the parallactic effect to average proper motion ranges from 0.6 to 0.9. The stars of all grades of brightness were found to be well mixed in each classification of proper motion. One third were as faint as eighth magnitude and three-quarters as faint as sixth, in these stars of relatively large motions. He determined the position of the solar apex from each proper motion class, and found an average position, R. A. 285°, Decl. +36°.

Since we know the velocity of the solar system in space, the parallactic effect in angle gives an approximate measure of distance, but this can only be applied for large numbers of stars in a group, for which we can assume that the mean of the individual stellar motions is close to zero, though individual stars may have a wide range of velocities, and may be travelling in every direction in space. The only direct method of measuring the distance of a star is by the measurement of its parallax. In general we expect that large proper motion may give measurable parallax, but this does not follow invariably, since the star may have exceptionally large motion of its own. Or the star

may be relatively near us, but moving nearly in the line of sight, giving only a small element of proper motion.

The measurement of radial velocities is independent of the distances of the stars, and does not contribute directly to the measure of their distances. But by furnishing an estimate of the parallactic effect for large numbers of stars, the radial velocity determinations contribute indirectly; just as the proper motions give their indirect contribution to the problem of the distances of the stars. Stellar parallaxes should in general be one-fourth the amount of the parallactic motion, since the distance travelled by the solar system in one year is about four times the radius of the orbit of the earth, and these two distances are the base lines for the measurement.

Lick Observatory, March 12, 1921.

INTERESTING FACTS ABOUT OUR OWN PLANET.

By CHARLES NEVERS HOLMES.

An equatorial journey "around our World" equals a distance approximating 24,900 miles—a distance crossed by light in less than 2/10th of a second, which would be travelled by a snail in about 34 years. Now, the Earth rotates once upon its axis in 24 hours, so that at a velocity approximating 24,900 miles per day a point on the equator would travel during the 20th Century about 909,000,000 miles. That is, it has traveled since the beginning of the Christian Era about 17,500,000,000 miles, or a distance equal to 188 times as far as it is to the Sun.

A journey to the centre of our Earth would approximate 3959 miles, and if we should ever sink a shaft there, excavating at the rate of 10 miles a year, it would take 4 centuries to reach the terrestrial centre. Now, 3959 miles do not seem very far, the extreme length of the United States, Atlantic to Pacific, being about 2800 miles, and the extreme length of North America being about 4500 miles. However, if we attempted to tunnel downward to the terrestrial centre, we should encounter stupendous difficulties of heat and pressure. It has been estimated that the temperature of molten lava ranges from 1200 to 2000 degrees, Centigrade, and it has also been estimated that at the Earth's centre the density may be as great as ten times that of water, resembling some very heavy metal. Therefore, it is improbable that during the present century we shall begin any tunnel to the terrestrial centre, although the time may be at hand when we shall sink deep shafts to tap and utilize the heat and other energies now hidden beneath our World's surface.

There is, however, an interesting fact about a shaft sunk from the surface to the centre of the Earth. As we all well know, each of us

possesses what is called "weight," due to the attraction between the Earth and our body. For example, one of us weighs "150 pounds" at the Earth's surface. If this individual could be weighed at the Sun's surface, he would weigh more than two tons! If at the Moon's, only 25 pounds. The reason for this difference in weight is, that surface gravity varies according to the respective weight and size of the Earth, Sun and Moon. Moreover, a man weighs "150 pounds" in one region of the Earth, and slightly less than that on the equator, inasmuch as at the equator the entire centrifugal force is pulling against the force of gravity. If a shaft could be sunk to the terrestrial centre, and a man weighing "150 pounds" should be lowered within it, this man would weigh only "112 1/2 pounds" at about 1000 miles below the surface. That is, he would lose one-quarter of his weight after descending one-quarter of the distance to the centre. Then, after descending one-half of the distance to the Earth's centre, he would weigh only one-half of "150 pounds." If this man reached the very centre of the Earth, he would have no weight at all. The explanation for such losses in weight is that at the terrestrial surface this man is drawn towards the terrestrial centre by full gravitative attraction, whereas, as he descends below the Earth's surface, it is as though were standing upon the surface of a smaller Earth, which would shrink in size and decrease in gravitative attraction in proportion as he approaches its centre. Accordingly, if this man could reach the *exact* centre of our Earth, there would then exist, no more gravitational units to attract his body. Surrounded by a terrestrial sphere approximating 260 billion cubic miles, his surface "weight" of 150 pounds would become a veritable cipher.

Nevertheless, although this man at the terrestrial centre has no weight himself, the Earth all around him has a stupendous weight. The man who once weighed "150 pounds," would be surrounded by a vast sphere, averaging a radius of 3959 miles in every direction. Inasmuch as the diameter of the Moon is only 2163 miles, it is evident that he could be surrounded by a number of such moons, each moon being equidistant about 898 miles from both the Earth's centre and surface. Therefore, it should not cause any surprise that the Earth is 49 times as large as its satellite the Moon. However, the weight of our Earth may cause some surprise—6,000,000,000,000,000,000,000 tons! Of course this is a mere cipher compared with the weight of the Sun, but, if we multiply this weight by 2000, or the number of pounds in a ton, we find that the Earth's weight approximates 12 septillion pounds. Possessing such a comparatively stupendous weight, our planet is able to chain us securely to its surface, and if we try to escape from that surface it ofttimes dashes us violently to the ground. The influence of its mighty *mass* is seen alike in a body's falling 16 feet during the first second, 64 feet during the first two seconds, and in the fact that, to escape forever from its sur-

face, a body must rise with a velocity of not less than 37,000 feet per second.

The Earth's 12 septillions of pounds are contained within a vast sphere possessing a bulk of about 260 billion cubic miles. Enclosing this vast sphere, there is a surface-area approximating 197,000,000 square miles. Upon this wide surface-area there dwell about 1,700,000,000 people, which would be an average of more than 8 people for each square mile of total surface, an average of about 30 for each square mile of land surface, and an average of about 561 people for each square mile occupied by the United States. Today the density of population in our 48 states averages about 35 citizens, per square mile. From the District of Columbia, which has more than 5,500 inhabitants in a square mile to the deepest depth in an ocean, the Pacific, 32088 feet, the distance is over 9000 miles. From Washington, D. C., to the highest height on the Globe, Mount Everest, 29002 feet, the distance is more than 9000 miles. From the deepest depth in an ocean to the highest height on the Globe, there is an altitude of 61,090 feet, 11.6 miles. If we remove our "150-pound man" from the Earth's centre and place him at the very bottom of the Pacific Ocean, his body will be under the terrific pressure of at least 13,500 tons. If we place this man upon the summit of Mount Everest, he would then be under a pressure of approximately only 5 tons.

A cubic foot of sea water has a weight of 64.3 pounds, and, accordingly, we should not be surprised that a man's body, placed at the very bottom of the Pacific Ocean, 32000 feet below its surface, would be crushed to a pulp by the pressure of water. At the surface of the sea there is an atmospheric pressure of 14.7 pounds upon every one of the 2000 square inches covering a human body, so that there our "150-pound man" would be surrounded by a total individual pressure of more than 14 tons. Fortunately, however, this exterior pressure inward is counteracted and neutralized by an equal interior pressure outward, for, otherwise, our bones would have to be stronger and harder to resist the atmospheric pressure. This atmospheric pressure becomes less and less as we ascend above sea level, and it is probable that the terrestrial atmosphere does not extend higher than 300 miles. However, our atmosphere approximates a volume of 60 billion cubic miles and a total weight of almost 6 quadrillion tons.

If we were able to ascend above our atmosphere and escape from the Earth, we should experience another interesting fact. It has already been stated that if we could descend far below the terrestrial surface, we should lose "weight" directly as the distance. That is, at one-fourth of the distance to the terrestrial centre, we should weigh only three-quarters of what we did at the surface, at one-half of the distance only one-half, and at the very centre we should possess no weight at all. Now, if we were able to ascend far above the terrestrial surface, we should find that we lose weight according to the square of the distance, *inversely*. Since the distance from Earth's surface to its

centre is about 4000 miles, then if our "150-pound man" could ascend 4000 miles above that surface, he would weigh only 1/4th as much as he did at the surface. For, having ascended 4000 miles, he would be twice as far as he was from the terrestrial centre, inasmuch as 8000 miles are twice 4000. Therefore, he would weigh 1/4th of 150 pounds, or 37 1/2 pounds. If he rose 8000 miles above the terrestrial surface, he would be 12000 miles from the terrestrial centre, thrice as far, since 12000 miles are thrice 4000, and, accordingly, he would weigh 1/9th of what he did, or 16 2/3rds pounds. Moreover, if he left the Earth 240,000 miles behind him, he would still possess some weight. This distance would be 60 times the Earth's radius, and, therefore, his weight would be diminished to 1/3600th of his terrestrial weight—a little more than 4/100ths of a pound. Now 240,000 miles are about the mean distance of our Earth from its Moon, and it is evident that 4/100ths of a pound, about 2/3rds of an ounce, represent the influence of terrestrial gravity upon our "150 pound man," were he placed on the lunar surface.

There are many, many more interesting facts about our Planet, many of which are discovered "under the microscope." One of these other facts is discovered "through the telescope,"—the indescribable minuteness of our Earth, compared with the indescribable vastness of the Universe. Our own "local Universe" is bounded by the so-called "Milky Way," and the distance across it, the diameter of the "Milky Way," has been variously estimated, one of these estimates approximating 6 quadrillion miles. If this estimate is correct, our planet, compared with our "local Universe," resembles a veritable pea situated within a circular area, an area so vast that it would take an aeroplane speeding 100 miles an hour approximately 70 million centuries to fly across it!

41 Arlington St., Newton, Mass.

THE "QUANTUM" EQUATION IN THE SOLAR SYSTEM.

By FERNANDO SANFORD.

Kepler's second law states that the area passed over by the radius vector of a planet in orbital motion is proportional to the time. This law may be written $\pi a b/T =$ a constant, where a and b are the semi-axes of the elliptical orbit and T is the periodic time. In the case of a circular orbit or an elliptical orbit of small eccentricity we may write $\pi R^2/T =$ a constant, where R is the mean radius of the orbit.

In such a case, the velocity of the planet in its orbit is $V = 2\pi R/T$ and $V^2 = 4\pi^2 R^2/T^2$. The kinetic energy of orbital motion then becomes $\frac{1}{2}mV^2 = 2\pi^2 R^2 m/T^2$. Since $R^2/T =$ a constant, we have for the second term of this equation k/T, where $k = 2\pi^2 R^2 m/T$.

We may then state the law that *the kinetic energy of orbital motion of a planet varies inversely as its periodic time;* or since its total orbital energy is twice its kinetic energy, we may write $E = k/T$.

When this equation is applied to the electrons in a radiating atom, it becomes the well known quantum equation, $E = h\nu$, where $\nu = 1/T$.

When the value of the constant R^2/T is calculated for each of the planets in the solar system some interesting relations appear. These relations are shown in Table I, where the values of R, T, and R^2/T are given for the different planets. In the fifth column under the heading m is given the series of whole numbers beginning with 3, and in the sixth column are given the quotients derived from dividing each value of R^2/T by its corresponding number. The values of R and T are given in terms of the earth's orbital radius and periodic time.

TABLE I.

Planet		R	T	R^2/T	m	Q
Mercury		0.387	0.243	0.618	3	0.206
Venus		0.723	0.615	0.850	4	.212
Earth		1.	1.	1.	5	.200
Eros		1.47	1.76	1.23	6	.205
Mars		1.52	1.88	1.23	6	.205
Asteroid	1.	*2.10*	*3.04*	*1.45*	7	.207
Asteroid	Ceres	2.76	4.60	1.656	8	.207
Asteroid	3.	*3.47*	*6.44*	*1.86*	9	.207
Asteroid	4.	*4.28*	*8.85*	*2.07*	10	.207
Jupiter		5.20	11.86	2.28	11	.207
Saturn		9.54	29.45	3.09	15	.206
Uranus		19.18	84.	4.39	21	.209
Neptune		30.05	164.8	5.48	26	.210

It will be seen that four groups of asteroids have been given places in the table, the asteroid Ceres being used as the representative of one group. The asteroid Eros, whose elements are also known, comes in the same group with Mars. The fact that the asteroids are divided into four groups was not known to the writer at the time when this table was first prepared; but on finding spaces for four planets, instead of one, between the orbits of Mars and Jupiter, the distribution of the asteroids was looked up, and Kirkwood's division into four groups was found.

The explanation of this separation into groups, as is doubtless known to all astronomers, is the perturbations produced by Jupiter and Mars, but especially by Jupiter on account of the enormous mass of this planet. Kirkwood called attention to the fact that asteroids whose periods are sub-multiples or simple fractions of sub-multiples of Jupiter's period would be in the same relative position as regards the sun and Jupiter at each revolution, or each small number of revolutions, of Jupiter, and their perturbations would, accordingly, accumulate until their orbits would become unstable. Thus periods of 1/2, 1/3, 1/4, 2/3, 3/4, etc., of Jupiter's period would be unstable.

Taking the average value of Q for the planets as 0.207, the periods

and distances of the groups giving values for m of 7, 8, 9, and 10 were computed and the values of T found were in all cases stable. The well known asteroid Ceres was taken as the representative of the second group, though twelve of the first one hundred asteroids discovered have periodic times between 4.55 and 4.65 years. In the first group there seems to be a grouping of periods about 3.64, instead of 3.04, as given by our equation. Thus there are fourteen of the first discovered one hundred asteroids whose periods lie between 1/3 the periodic time of Jupiter and twice the periodic time of Mars. Their average period is 3.64 years. Their eccentricities are great, and the expression R^2/T does not apply as closely to them as to the planets. Thus the asteroid Urania, whose period is 3.64 years, has for its greatest and least distance from the sun, $a = 2.66$, $b = 2.06$, making $ab/T = 1.50$ and $Q = 0.214$.

Of the 172 asteroids given in Newcomb's *Popular Astronomy* there are but four with periods of over six years. Their average periods are 6.32 years and their average value of Q is about 0.200. In the above-mentioned list no asteroid with a period as great as seven years is given. The asteroid Eros, whose orbit lies partly within and partly without the orbit of Mars, was found to give the same value of R^2/T as is given by Mars.

Values of T and R for the three planets for which there seems to be room between the orbits of Jupiter and Saturn were calculated from the equations $R^2/T = 0.207m$ and Kepler's third law, $R^3 = T^2$. They were found to fall in perfectly tenable positions in all cases, as did several of the positions calculated outside the orbit of Saturn. No case was found for which the formula gave an untenable position for a planet.

The positions of planets as regards their freedom from perturbations, if not determined by the law observed by Kirkwood, seem to have been selected with foresight. Thus Mars, whose small mass would seem to make the planet especially susceptible to perturbations by Jupiter, has a periodic time half way between 1/6 and 1/7 of Jupiter's period. Saturn has a period midway between two and three times the period of Jupiter and almost midway between 1/3 and 5/12 the period of Uranus.

It seems plain that an equation for the periodic time of planets in the form $1/T = 0.207\ (m/R^2)$, where m stands for the successive whole numbers from 3 on, will give perfectly tenable planetary positions and that all known planets occupy very approximately positions given by this series. This is also true for the satellites of Jupiter and Saturn, to which the formula applies with about the same degree of accuracy as to the planets.

It is also possible to derive a very simple approximate expression for the planetary distances from this equation.

Thus,

$$R^2/T = mQ$$

and

$$R^4/T^2 = m^2Q^2.$$

But

$$R^3 = T^2,$$

hence

$$R = m^2Q^2 = 0.0428m^2.$$

In Table II the values of R calculated from the above equation are compared with the observed values.

TABLE II.

Planet	R Calc.	R Obs.	% dif.
Mercury	0.385	0.387	—0.52
Venus	0.685	0.723	—5.2
Earth	1.07	1.	+7.0
Mars	1.54	1.52	+1.3
Jupiter	5.17	5.20	—0.58
Saturn	9.63	9.54	+0.93
Uranus	18.9	19.18	—1.5
Neptune	28.9	30.05	—3.8

No claim is made for accuracy in the above computations. They are intended to be only approximations, and it is not unlikely that a better value of Q than 0.207 may be found. However the results seem to the writer to indicate a true law of planetary arrangement. They seem also to suggest possible groups of asteroids between all the pairs of outer planets.

Palo Alto, Cal., February 1, 1921.

THE INTERNATIONAL DATE LINE.

By ROSCOE LAMONT.

In his "Handy Book of Curious Information," Walsh explains in considerable detail the International Date Line, tracing its irregular course from the North to the South Pole, and says that on reaching this line ships change their reckoning; that if they are sailing eastward they drop one day, but if sailing westward they repeat one day. He conforms to the Episcopal Prayer Book which says: "We have left undone those things which we ought to have done, and we have done those things which we ought not to have done"; for he has done going east what he ought to have done going west, and he has done going west what he ought to have done going east. To explain the matter by means of a simple illustration, we may suppose a case which it is not difficult to imagine at the present time.

A man starts in an airship from London Monday noon, July fourth, to fly around the world, going west, and he announces that he will make fifteen degrees of longitude each day. Since there are 360 degrees

to cover, twenty-four days will be required to complete the journey, and he marks on the calendar Thursday noon, July 28, as the time of his return. He makes fifteen degrees of longitude a day, but in so doing his day is twenty-five hours long. He returns to London on schedule time, having seen the sun rise twenty-four times, reaching London Thursday noon, July 28 (so he says). Since he has had twenty-four days and each day contained twenty-five hours, the number of hours elapsed is equal to twenty-four times twenty-five or six hundred.

His friend who has stayed in London has also lived six hundred hours since the beginning of the air journey, but his day is twenty-four hours long, and six hundred divided by twenty-four gives twenty-five, the number of days elapsed for him. He congratulates the airman on making a trip around the world in twenty-five days, getting back Friday noon, July 29. The airman says he made the trip in twenty-four days. The other says it took him twenty-five. They are both right. The word day has not the same meaning for each of them. To the one it denotes a period of twenty-five hours and to the other a period of twenty-four hours, but the number of hours is the same in the two cases, as twenty-four days of twenty-five hours each are the same as twenty-five days of twenty-four hours each.

But the airman, in order to think the matter out clearly, decides to take the trip again, go west as before, and make fifteen degrees of longitude from noon to noon. He leaves London Monday noon, August first, saying that he doesn't know just what day he will return, that he ought to be back on August twenty-fifth, but might not show up until the twenty-sixth. After twelve days of twenty-five hours each have elapsed he finds himself at the 180th meridian, Saturday noon, August thirteenth. He begins to do a little figuring. Three hundred hours have passed since leaving London and these make twelve and one-half days for his London friend, for whom it is Saturday midnight, August thirteenth. He decides to call his time Sunday noon, August fourteenth, skipping a day, seeing his London friend and going him twelve better. He is then twelve hours in advance of London time. But twelve days of twenty-five hours each will pass before he reaches London, and although he leaves the 180th meridian twelve hours in advance of London time, these twelve hours are absorbed, swallowed up, by his twelve days of twenty-five hours each (one hour each day), and he arrives in London Friday noon, August twenty-sixth, agreeing exactly with the London clock and calendar.

It was not at all necessary to change the day at the 180th meridian in order to agree with the London day on return. The change could have been made at any place, but the International Date Line which has been agreed upon coincides approximately with the 180th meridian, and as that is the place where the day *first begins*, (Sunday, August fourteenth, having begun *there* twelve hours before his arrival), unless the change had been made at that line, the airman's day, after leaving it,

would not have agreed with the day of the countries over which he travelled until the change was made.

Going east the same reasoning would apply, but in making fifteen degrees of longitude from noon to noon his day would contain only twenty-three hours, and getting around in twenty-four days 552 hours would pass, equal to twenty-three London days, and therefore some day of the week and month would have to be counted twice in order to agree with the London reckoning on return.

When the world was circumnavigated for the first time by the explorers led by Magellan, since they sailed toward the west, the same direction the sun moves in its daily course, the sun had to overtake them each day they made any westerly distance, thus increasing the length of the day; but the law of compensation operated even here, for they found when they got around the world, much to their surprise, that having had longer days than the folks at home they hadn't had as many. The few survivors of the expedition (Magellan perishing) completed the journey in 1522, and one of the members named Pigafetta wrote an account of the voyage. An English translation of this work was published in Cleveland, Ohio, in 1906, and this is what Pigafetta says about the surprise of the circumnavigators when they learned, on nearing home, that in their reckoning they were one day behind the Portuguese:

"Finally, constrained by our great extremity, we went to the Cape Verde Islands. Wednesday, July 9, we reached one of those islands called Saint James and immediately sent the boat ashore for food. . . . . We charged our men when they went ashore in the boat to ask what day it was, and they told us that it was Thursday with the Portuguese. We were greatly surprised for it was Wednesday with us, and we could not see how we had made a mistake; for as I had always kept well, I had set down every day without any interruption. However, as was told us later, it was no error, but as the voyage had been made continually toward the west and we had returned to the same place as does the sun, we had made that gain of twenty-four hours, as is clearly seen."

In "The Decades of the newe worlde. . . . wrytten in the Latine tounge by Peter Martyr of Angleria, and translated into Englysshe by Rycharde Eden", published in London in 1555, Eden speaks of the strange disagreement in the days which the Spaniards found on return from their trip around the world, and of the great philosopher and astronomer who explained it after their arrival at Seville in the ship Victoria, and this passage is quoted with the sixteenth century spelling of the "Englysshe tounge":

"And amonge other notable thynges by hym (Peter Martyr) wrytten as touchynge that vyage, this is one, that the Spanyardes hauynge sayled abowt three yeares and one moneth, and the most of them notynge the dayes, day by day (as is the manner of all them that sayles by the Ocean), they found when they were returned to Spayne, that they had loste one day. So that at theyr arryuall at the porte of Siuile beinge the seuenth day of September, was by theyr accompt but the sixth day And where as Don Peter Martyr declared the strange effecte of this thynge to a certeyne excellente man who for his singular lernynge was greatly aduaunced to honoure in his common welthe and made Themperours ambassadoure, this woorthy gentelman who was also a greate Philosopher and Astronomer, answered that it coulde not otherwyse chaunce unto them

hauynge sayled three years continually, euer folowynge the soonne towarde the West. And sayde furthermore that they of owlde tyme obserued that all suche as sayled behinde the soonne towards the West, dyd greatly lengthen the day."

The great philosopher and astronomer referred to was Gasparo Contarini of Venice (1483-1542), created a cardinal in 1535 by Pope Paul III. He was considered one of the great scholars of his time, was a student at the University of Padua about the time Copernicus was there, and was the author of many books on historical and religious subjects, some of which were translated into English.

In the Fifth Decade (not translated by Eden) Peter Martyr says that when he heard the sailors speak of the lost day he told them that perhaps the priests had deceived them by omitting it in their celebrations, but they said that that was impossible. If the priests had omitted one day (a day of the month and a day of the week), they would have done exactly what navigators do today at the International Date Line when sailing west, and on return home their day would have agreed with the day of the place at which they landed. But supposing there was no difference in reckoning caused by a trip around the world (and Peter Martyr of course supposed this), if in that case a day had been omitted, on return they would have been one day in advance instead of one day behind. The only way in such a case to be one day behind would be to repeat one day, as Mr. Walsh does when going west.

He also suggested that they might have forgotten that the year 1520 was a leap year and have given to February of that year only twenty-eight days, but the sailors declared that February 1520 received twenty-nine days. This, however, would not have explained anything. If the sailors had given February 1520 only twenty-eight days, and if there had been *no other reason* for a disagreement in the reckoning, on their arrival at the Cape Verde Islands, where they found the day to be Thursday, July 10, on board ship it would have been Thursday, July 11, whereas it was Wednesday, July 9. But with the state of things as they existed, having one day less sailing west around the world, if the year 1520 had been made a common year, their day on reaching the Island of Saint James would have been Wednesday, July 10. Peter Martyr was more than puzzled as he admits.

"Being much disquieted and troubled with that care, I conferred with Gasparo Contarini (a man not meanly instructed in all kinds of literature), who was then ambassador with the Emperor for his famous commonwealth of Venice. Whereby we know (discussing the matter with divers arguments) that this strange report, never heard before, might very well be after this manner: This Castilian ship set sail from the Islands of Gorgades towards the west, which way also the sun goeth. Thence it came to pass that having followed the sun, they had every day longer according to the quantity of the way they made, wherefore having perfited (compassed) the circle, which the sun performeth in twenty-four hours towards the west, it consumed and spent one whole day, therefore it had fewer days by one than they who have that space of time kept one certain place of abode. But if the Portugal fleet, which saileth toward the east, should return again unto the Gorgades, continuing their course unto the east by this way and navigation, now first found and discovered to mortal men, no man would doubt, seeing they should have shorter days, having perfited the circle, but that twenty-four whole hours should remain unto them over and above, and so one whole day, wherefore they should reckon more by one. And so

if either fleet, to wit, the Castilian and the Portugal, had set sail the same day from the Gorgades, and the Castilian had sailed toward the west and the Portugal had toward the east, turning stern to stern, and had returned to the Gorgades by these divers ways in the same space of time and at the same moment, if that day had been Thursday to the Gorgades, it had been Wednesday to the Castilian, to whom a whole day was consumed into longer days. But to the Portugal, to whom by shortening of the days one day remained over and above, the same day should be Friday. Let philosophers more deeply discuss this matter, we yield these reasons for the present."[1]

The reasons yielded then need no addition or correction now (except in one minor point); but bearing in mind the explanations offered by Peter Martyr on his own account, there is no reason to doubt the statement of Richard Eden, that "this strange report, never heard before", was comprehended and explained by "a certeyne excellente man who for his singuler lernynge was greatly aduaunced to honoure in his common welthe", Gasparo Contarini of Venice.[2]

The International Date Line, although it may not be fixed by international agreement, is the place generally adopted as the one most convenient for changing from one day to another. Such a line might be established anywhere on the earth, but there would be disadvantages in having it pass through an inhabited region. To keep track of the zones of time when traveling is trouble enough, skipping an hour or repeating an hour, without running into the date line unexpectedly and having to skip a day or repeat a day. A number of amusing mistakes have been recorded, caused by the date line passing between neighboring places, one of which is noted farther on. In some cities by crossing the street a person can enter another state, but if the date line ran through a city, enabling a person to pass at will from one day to another, he could skip Sunday, have two consecutive Saturdays, and celebrate the fourth of July twice in one week, as the King of Samoa did in 1892 in order to get on the American side of the line. In the "Letters from Samoa" of Mrs. M. I. Stevenson (mother of Robert Louis Stevenson) there is one dated the second 4th July 1892, beginning as follows:

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[1]Translated by Michael Lok, London, 1612. The spelling has been modernized.

[2]The passage quoted from Richard Eden is almost a literal translation made by him from the Italian of Ramusio as given in his Navigations and Voyages, Vol. 1, page 374, published in Venice in 1550. Ramusio does not call the man whom Peter Martyr consulted an astronomer, but "a very great philosopher, instructed in the Greek and Latin literature, of singular learning and rare excellence." The Emperor's Court was at Valladolid, where both Peter Martyr and Contarini were staying, and whither repaired the eighteen survivors who returned to Seville in the Victoria to present themselves before the Emperor. Thirteen men were detained at the Cape Verde Islands by the Portuguese when they found out that the Spaniards had been around the world, and Herrera, a Spanish historian of the sixteenth century, gives the names of thirty-one men who appeared at Court, but Peter Martyr speaks of only eighteen whom he interviewed. Herrera says that the men of the Victoria, because of a day's difference in the reckoning, ate meat on Friday, but according to Pigafetta's account they had nothing but rice and water for food and drink, all the meat having putrefied for want of salt. They had many remarkable escapes during the voyage.

Peter Martyr says that the Gorgades are called by the King of Portugal the Cape Verde Islands.

"Surely now I have been round the world, since at last I have done that to which I used to look forward, I have 'gained a day.' It seems that all this time we have been counting wrong, because in former days communication was entirely with Australia, and it was simpler and in every way more natural to follow the Australian calendar; but now that so many vessels come from San Francisco, the powers that be have decided to set this right, and to adopt the date that belongs to our actual geographical position. To this end, therefore, we are ordered to keep two Mondays in this week, which will get us straight."

No doubt many persons look forward to the time when they will be able to gain a day or lose a day by crossing the date line, which seems to be a permanent institution. The only way to get rid of it is to abandon the various zones of standard time of fifteen degrees each and have one zone of standard time for the whole world, beginning the day everywhere, regardless of sun time, when it begins at the prime meridian in England and counting the hours up to twenty-four, the Greenwich day being regulated by the sun, but the sun at all other places being merely "to give light upon the earth" and not to rule the day; and while this system would have its advantages—a person when traveling would never have to change the time as the time would be the same everywhere—yet there would be disadvantages as well. To know what day of the week it was one would have to look at the clock (which is the case even now for night workers), as a new day would begin when the hour hand was at twenty-four whatever the position of the sun in the heavens.

Some of the English have advocated this system (Professor Newcomb said it would be a good scheme for the millennium), but as long as the day is dispensed, so to speak, into zones, the date line cannot be dispensed with. But it is placed where it will cause the least inconvenience—in the Pacific Ocean. Another advantage of this location is that the meridian 180 degrees from Greenwich, from which place longitude is now reckoned by almost all countries, passes through that ocean. The line does not follow the meridian closely, but it is fixed according to the principle of the self-determination of peoples and their right to decide by what day they shall live and die. To lay down the line with exactness it is necessary to know which islands near the 180th meridian follow the American day and which the Asiatic day and then run the line accordingly. This information has been obtained and maps showing the location of the line are published by the Government.

Since the local time is different for all places on the earth which differ in longitude, every possible time of the day or night, as shown by a clock, is at every moment the mean solar or local time of some terrestrial meridian. All parts of the earth, therefore, can not have the same day except for an instant, and the meridian where the day is first ending has one adjoining it on the east where the same day is just beginning. Each day, as Wednesday, begins in New York before it does in Chicago, it begins in London before it does in New York, but where does Wednesday first begin? It is necessary to decide upon some place where the day begins before it begins anywhere else, and this place is called the date line since the day dates from that line,

though some people might think that "the line of confusion", spoken of by Isaiah, would be a good name for it. When Wednesday begins at the date line it is Tuesday everywhere else (considering the line to coincide with the meridian and using local time), and Wednesday begins continuously westward around the world as the various places have the midnight hour of Tuesday. The line is a party wall between two hemispheres separating the days. When the region adjoining it on the east is ready for Wednesday to begin, the date line has passed through all of Wednesday and is ready for Thursday. If a traveler, coming from the Philippines, reaches the line when Thursday is just beginning there, when he crosses it he enters the region where Wednesday is just beginning, and although he has finished with Wednesday once he has got to go over it again. Another traveler, crossing the line at the same time in the opposite direction, will have no day named Wednesday, and of course the corresponding day of the month will also be repeated or skipped the same as the day of the week.

"The line is not only imaginary; it has not even an astronomical reason for its existence, like the equator. It is purely and entirely an arbitrary convention; and yet its position is of exceeding importance to mankind. From the very convenience of this position we are apt to forget its value; for the line is the great day-origin. It sets, not the time of day merely, but the day itself. At the line two days meet. There, though time flows ceaselessly on, occurs that unnatural yet unavoidable jump of twenty-four hours; and no one is there to be startled by the fact—no one to be perplexed in trying to reconcile the two incongruities, continuous time and discontinuous day. There is nothing but the ocean and that is tenantless."[1]

Although the Philippine Islands are now on the Asiatic side of the date line, this was not always the case, for from the time of their settlement by the Spaniards until January 1, 1845, they were on the American side. In the neighboring islands that were settled by the Portuguese, who had come by way of the Cape of Good Hope, the dates were one day in advance of those in the Philippines. The Spaniards and Portuguese in Europe had the same calendar and their days corresponded, but they sailed to the east by different routes, the Spaniards going west, following the sun, and their time getting farther behind gradually, the Portuguese going east, meeting the sun, and their time getting farther ahead, and thus when the Spaniards arrived in the Philippines they were sixteen hours behind European time, and the Portuguese on reaching their possessions were eight hours in advance, making a difference of one day, Saturday with the Spaniards being Sunday with the Portuguese. The Gregorian calendar was introduced into the Philippines in 1584, the day following October fourth being called the fifteenth, but the Portuguese still continued to be one day in advance. This difference existed for about three centuries, but, although its cause was well known, there was no advantage to the Spaniards in making a change. Their trade was principally with Spanish America, and to follow the American day was more convenient than

[1]Percival Lowell: The Land of the Morning Calm, A Sketch of Korea.

to agree with the Portuguese and have to skip a day or repeat a day every time they crossed the Pacific. They called he Philippines the Islas de Poniente (Islands of the West), considering them to lie at the western extremity of their hemisphere. When the Spaniards were celebrating Easter the Portuguese were gathering the spices on Monday, but as they disagreed with the Portuguese about almost everything, it seemed natural enough to have the days of the week disagree.

This disagreement in the reckoning was sometimes lost sight of, and Acosta, a Spanish historian of the sixteenth century, tells about a priest who set out from the Philippines, and on arriving at Macao went to celebrate mass on the day of Saint Athanasius (according to his reckoning), and when he got to church found it was another day. This is how Acosta tells it, the translation being by Edward Grimston, published in London in 1604:

> "It happened to father Alonse Sanches, of whom mention is made before, that parting from the Philippines, he arrived at Macao the second day of Maie, according to their computation, and going to say the Masse of S. Athanasius, he found they did celebrate the feast of the invention of the holy Crosse, for that they did then reckon the third of Maie."

Acosta then proceeds to give a long explanation, and a very clear one, of the cause of the difference.

After Spain had lost her possessions in America, it was more convenient to have the Phillipines and the mother country on the same side of the date line, so that ships trading between them by way of the Cape of Good Hope would not have to change the day, and in 1844 a decree was issued by the Governor-General of the Philippines, Claveria, directing that the day following Monday, December 30, 1844, be called Wednesday, January 1, 1845.—Tuesday, December 31, not being counted. In the English translation of Jagor's "Travels in the Philippines" (London, 1875), there is the following with reference to this omission of one day:

> "It was still, over there, the last day of the old year while the rest of the world was commencing the new one, and this state of things continued till the close of 1844, when it was resolved, with the approval of the archbishop, to pass over New Year's eve for once altogether. Since that time the Philippines lie no longer in the distant west, but in the far east, and are about eight hours in advance of their mother country."

Their mother country has changed since Jagor wrote, but they have maintained their lead and even increased it. Previous to 1845 the Filipinos were the last people in the world to go to bed on Saturday night, they were the last to get up on Sunday morning. But this is no longer the case. Instead of lagging behind the rest of the world they are among the leaders, their local time being more than thirteen hours in advance of that of the capital of the United States. (By standard time just thirteen hours in advance). Manila is 198 degrees east of Washington or 162 degrees west. Setting out towards the east the watch is advanced one hour every fifteen degrees, and on arriving at Manila it has been put forward 13-1/5 hours. Proceeding west the watch is put back one hour every fifteen degrees, and since there are

103 degrees from Washington to the date line, when the line is reached the watch has been turned back 6-13/15 hours. But on crossing the date line a day is dropped, and the hour hand of the watch may be given two complete revolutions in the forward direction (if desired) to indicate this gain of 24 hours. There are still 59 degrees to pass over, and 59 divided by 15 gives 3-14/15, and by adding 6-13/15 and 3-14/15 we obtain 10-4/5. Then by subtracting 10-4/5, the number of hours the watch has been turned back, from 24, the number it has been put forward, there remain 13-1/5 hours as a net gain, the same result as before.

Some perhaps will say: Isaiah was right, a line of confusion was stretched out upon the earth and it is in the Pacific Ocean.

Washington, D. C.

Inhabitants of Betelgeuse.—

Inhabitants of Betelgeuse,
Do you take interest in the views
Of men of science who discuss
The parallax and radius
Of your gigantic star?
And in the deep design of fate
Are you e'er swayed by love or hate?
And are you plagued with hopes and fears,
With politicians, profiteers,
Diplomacy and war?

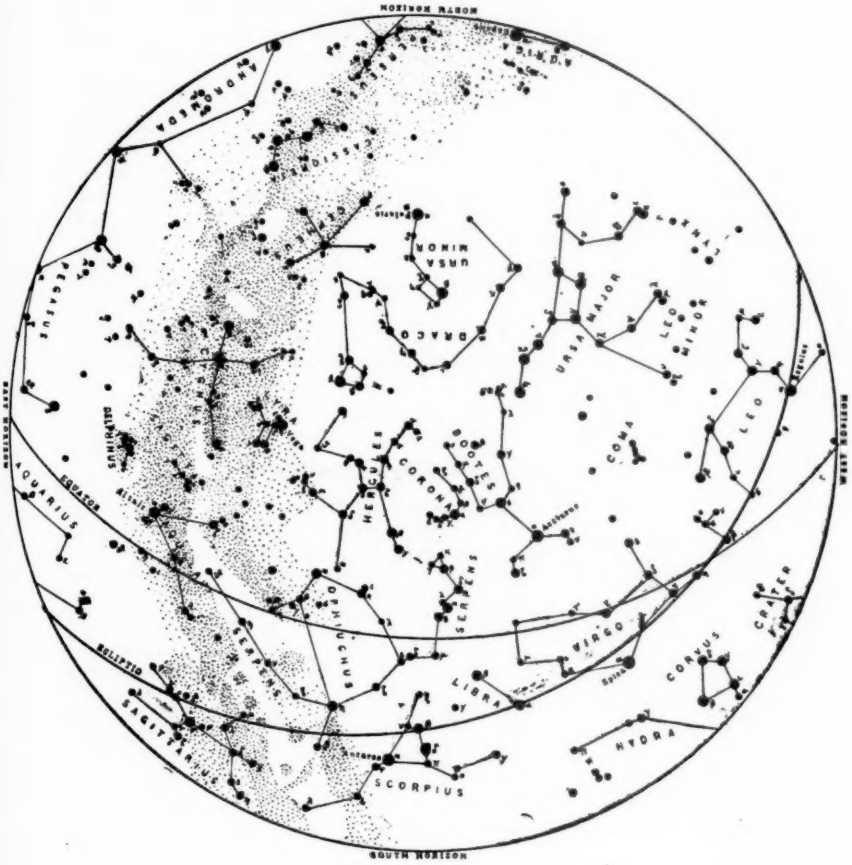
Have you discovered how to fly
Through countless leagues of azure sky?
Can your rich men, imperious,
Take little jaunts to Sirius,
Returning the next day?
And when you send an etherplane
Out on a trip to Charles's Wain,
Do you get word by radio
If it is forced through rain or snow
Across the Milky Way?

Inhabitants of Betelgeuse,
Do kindly let us have some news
Of how the last election went
In yonder starry firmament
Beyond our blazing sun.
And if you have a baseball nine
Please condescend to drop a line
Of sympathy for those who reeled
Before the victors on the field
And praise for those who won.

Inhabitants of Betelgeuse,
Please don't get mad if someone does
Pronounce to rhyme with "news" and "views,"
With "booze" and "lose" and "overshoes,"
The title of your sphere.
If you who live on Betelgeuse
Can hear our telephonic buzz,
We call to you with all our strength,
O'er fancied wire of untold length,
"A gay and glad New Year."

Providence, R. I., Feb. 1921. M. McArt.

PLANET NOTES FOR JULY AND AUGUST, 1921.



THE CONSTELLATIONS AT 9:00 P. M. JULY 1.

The *moon's* phases will occur as follows:

New Moon	July	5	at 7:36.3	A.M.	C.S.T.
First Quarter		11	" 10:15.7	P.M.	"
Full Moon		19	" 6: 7.7	"	"
Last Quarter		27	" 8:19.9	"	"
New Moon	Aug.	3	" 2:17.5	"	"
First Quarter		10	" 8:13.7	A.M.	"
Full Moon		18	" 9:28.3	"	"
Last Quarter		26	" 6:51.4	"	"

Mercury will pass inferior conjunction on July 7, will be at greatest western elongation July 28, will be in perihelion Aug. 10 and at superior conjunction

Aug. 22. The elongation will be less than 20° so that the planet will be seen, if at all, with considerable difficulty in the morning before sunrise.

Venus will reach greatest western elongation July 1 at a distance of 45° 44′ from the sun. During the night following, the planet will be in conjunction with the moon and pass less than half a degree from the limb of our satellite.

The earth will be in aphelion July 4 at 1:00 A.M. Central Standard Time.

Mars will be too far from the earth and too near the sun for satisfactory observation during this time.

During July *Jupiter* and *Saturn* may still be observed in the early evening but by Aug. 1 they will be only three hours from the sun and therefore comparatively low in the west when darkness falls.

Uranus will reach opposition on the last of August and therefore be in the best position for observation.

Neptune will be in conjunction with the sun Aug. 6 and therefore unfavorably situated for observation during the entire summer.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1921	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle E from N	EMERSION. Washington M.T.	EMERSION. Angle E from N	Duration
			h m	°	h m	°	h m
July 7	ω Leonis	5.5	8 39	182	8 54	215	0 15
9	359 B Leonis	6.3	9 22	100	10 17	299	0 55
18	ρ Sagittarii	4.0	15 11	127	15 52	200	0 41
21	c^2 Capricorni	6.3	16 14	11	17 2	298	0 48
25	147 B Piscium	5.9	13 20	79	14 38	229	1 17
29	δ Tauri	3.9	16 8	65	17 18	268	1 10
31	292 B Orionis	6.5	15 6	135	15 42	220	0 36
Aug. 10	32 Librae	5.9	6 42	66	7 52	320	1 10
10	ξ Librae	5.6	9 51	50	10 40	322	0 49
22	88 Piscium	6.2	8 5	93	8 56	231	0 51

Astronomical Observatory at Tacubaya is sending time signals through the Chapultepec Radio Station at $0^h\ 55^m$ to $1^h\ 0^m\ 0^s$, Greenwich Civil time, using the same form as Arlington does. The wave-length is 5800 meters. This hour corresponds to six P. M. of the 105° meridian time. At local noon other signals are sent during 3^m with wave-length of 1,200 meters. The time signals at 1 A. M. (G. T.) can be heard in U. S. and Central and South America.

JOAQUIN GALLO.

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1921					
					July				August	
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8		22 2		25 23		
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	4 15	19 23	4 8	19 16		
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	10 23	25 20	9 17	24 13		
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	11 12	26 11	10 10	25 9		
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	9 15	21 20	9 4	27 13		
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	12 0	26 7	9 14	23 21		
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	12 23	26 17	9 10	23 3		
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	8 21	23 5	13 18	28 2		
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	9 12	27 1	4 20	22 9		
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	10 6	26 3	3 2	19 0		
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	4 11		5 19			
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	6 22	24 3	10 10	27 15		
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	6 13	20 3	9 12	23 2		
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	3 13	27 6	12 2	27 21		
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	3 16	20 7	5 21	22 12		
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	5 13	21 8	6 3	21 22		
RW Persei	13.3	+42 04	8.8—11.0	13 04.8	11 6	24 11	6 16	19 20		
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	12 4	31 1	18 22	28 9		
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	7 12	19 23	1 9	26 5		
TT Aurigæ	5 02.8	+39 27	7.8— 8.7	0 16.0	6 12	19 20	8 20	22 4		
RY Aurigæ	11.5	+38 13	10.7—11.7	2 17.5	5 18	22 3	7 12	23 20		
RZ Aurigæ	42.9	+31 40	10.6—13.3	3 00.3	10 11	22 12	9 13	21 5		
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	7 11	24 19	2 11	19 19		
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	4 8	25 4	4 14	25 9		
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	6 20	22 20	7 21	23 12		
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	7 21	25 2	5 12	22 17		
U Columbæ	6 11.2	−33 03	9.2—10.0	2 19.2	9 15	20 20	6 15	23 10		
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	4 1	20 11	5 21	22 6		
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	9 10	24 16	8 22	24 4		
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	6 18	18 23	12 9	24 14		
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	6 16	20 23	11 12	25 20		
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	9 8	22 23	5 14	26 1		
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	8 11	27 2	5 9	23 23		
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	6 19	20 2	8 20	22 2		
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	9 20	26 15	12 10	29 5		
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	8 12	21 8	9 15	28 22		
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	4 9	18 22	9 18	24 7		
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	1 22	18 4	3 10	19 16		
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	10 13	29 12	8 0	26 23		
RX Hydræ	9 00.8	— 7 52	9.1—10.5	2 6.8	8 6	21 23	11 11	25 4		
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	6 5	24 0	10 19	22 16		
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	5 16	19 4	8 9	22 21		
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	9 4	24 0	7 20	22 16		
SS Carinæ	10 54.2	−61 23	12.2—12.8	3 07.2	10 3	23 8	5 13	25 8		
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	4 10	22 0	8 15	26 5		
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	7 16	22 8	6 0	20 16		
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3 22	24 6	6 20	20 10		
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	9 5	24 5	8 6	23 6		
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.1	7 8	26 13	5 3	24 7		
SS Centauri	07.2	−63 37	8.8—10.4	2 11.5	6 6	21 3	5 0	19 21		
133926 Hydræ	13 39.0	−26 23	8.6—12.7	2 21.5	4 12	21 21	8 6	25 15		

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1921							
					July				August			
	h m	° ′		d h	d	h	d	h	d	h	d	h
δ Libræ	14 55.6	— 8 07	4.8— 6.2	2 07.9	9	6	23	5	13	4	27	13
U Coronæ	15 14.1	+32 01	7.6— 8.7	3 10.9	8	3	28	20	11	15	25	11
TW Draconis	15 32.4	+64 14	7.3— 8.9	2 19.3	9	12	26	8	12	5	29	1
SS Librae	15 43.4	—15 14	9.3—11.5	0 18.4	6	15	21	22	6	6	21	13
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	10	19	25	11	9	4	23	20
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	5	17	22	5	7	17	24	5
R Aræ	31.1	—56 48	6.8— 7.9	4 10.2	4	10	22	3	8	20	26	13
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	4	14	25	8	4	1	24	19
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	11	19	25	10	8	0	21	14
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	4	22	21	17	7	11	24	6
μ Herculis	13.6	+33 12	4.6— 5.4	2 01.2	7	4	19	11	6	22	25	9
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	5	21	18	6	5	19	18	3
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	12	21	27	15	11	9	26	3
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	9	5	25	13	10	22	27	7
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	3	19	18	21	10	12	25	14
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	11	17	27	5	11	17	27	5
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	9	14	25	14	10	13	26	12
WX Sagittarii	53.6	—17 24	9.2—10.8	2 03.1	6	21	23	22	9	23	26	23
WY Sagittarii	17 54.9	—23 1	9.5—10.6	4 16.0	10	0	27	16	7	0	24	17
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	9	18	30	10	9	18	30	11
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	5	13	20	1	3	13	18	1
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	13	4	27	23	9	19	23	15
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2	6	16	21	19	5	22	21	1
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	4	18	19	2	2	10	23	21
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	12	14	26	9	9	15	23	21
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	3	20	20	11	6	2	22	17
RR Draconis	40.8	+62 34	9.3—13	2 19.9	7	12	24	12	2	0	18	23
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	7	9	20	16	9	15	22	22
β Lyræ	46.4	+33 15	3.4— 4.1	12 21.8	12	11	25	9	7	7	20	5
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	2	4	17	11	1	17	24	15
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	4	6	19	9	3	13	18	16
RV Lyræ	12.5	+32 15	11. —12.8	3 14.4	6	20	21	5	4	15	26	5
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	9	17	27	14	5	13	23	11
U Sagittæ	14.4	+19 26	6.5— 9.0	3 09.1	6	10	19	23	2	12	22	18
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	5	5	27	7	3	16	25	18
TT Lyræ	24.3	+41 30	9.4—11.6	5 05.8	8	7	24	1	3	13	24	12
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	8	15	21	16	3	17	23	7
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	8	13	20	13	7	13	25	14
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	5	21	19	4	8	1	21	8
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	5	13	23	20	2	0	20	7
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	2	17	19	13	13	20	30	17
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	8	16	22	6	4	19	25	4
UW Cygni	19.6	+42 55	10.5—13	3 10.8	7	17	21	12	4	7	26	0
V Vulpec.	32.3	+26 15	8.2— 9.8	37 19.0	2	12			9	7		
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	8	8	27	14	6	4	25	10
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	8	7	26	17	4	21	23	7
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	8	3	23	3	7	2	22	2
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	8	23	24	5	8	10	22	14
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	2	3	22	8	11	13	31	18
VVCygni	21 02.3	+45 23	12.1—13.8	1 11.4	5	0	19	18	10	22	25	17
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	5	10	24	20	3	12	22	21
RY Aquarii	14.8	—11 14	8.8—10.4	1 23.2	1	14	16	18	9	9	25	3
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	2	20	23	3	2	6	22	13
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	10	1			10	8		
RW Lacertæ	22 40.6	+49 08	10.2—11.2	5 04.4	16	21	22	11	6	23	22	13
8.1914 Pegasi	51.7	+32 41	10.0—10.6	5 06.4	7	1	22	20	2	9	23	11
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.4	1	22	26	19	4	2	20	16
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.3	7	5	22	6	13	20	28	22
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	3	22	20	10	5	22	22	9

Maxima of Variable Stars of Short Period.

[Calculated by members of the class in General Astronomy at Carleton College.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

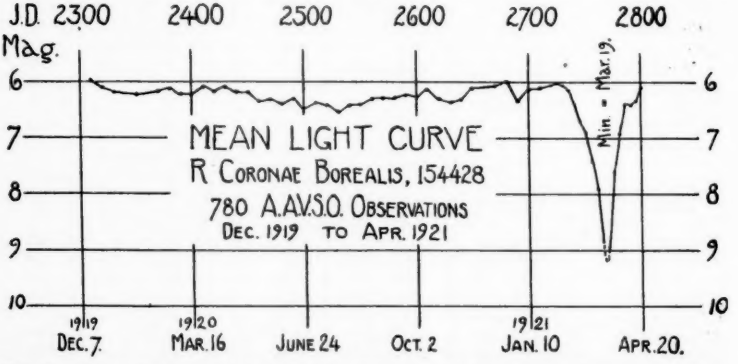
Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1921					
					July				August	
	h m	° ′		d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7		14 11			20 0	
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	13 23	30 6	15 13		23 16	
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	10 1	25 1	10 11		25 23	
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	7 22	22 17	6 12		21 7	
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	7 4	23 1	7 23		23 20	
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	10 3	25 17	10 7		25 21	
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	12 20	27 9	10 23		25 13	
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	10	26	11		27	
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	2 11	19 15	5 18		22 23	
SV Persei	42.8	+42 07	8.8— 9.6	11 03 1	1 7	23 13	3 16		25 23	
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	2 1	25 7	5 22		29 4	
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	5 19	21 3	5 10		20 18	
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3	10 15	30 22	10 1		30 8	
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	6 2	21 12	5 23		21 9	
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	9 15	20 16	6 6		22 21	
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	4 2	26 19	3 8		18 12	
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		25 15			21 15	
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	6 14	21 7	5 5		20 3	
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	5 1	19 11	2 20		24 11	
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	5 9	21 5	13 23		29 19	
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4 23	25 6	4 10		24 17	
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5	4 17	26 23	18 6			
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	6 23	22 20	7 17		23 15	
V Carinæ	8 26.7	—59 47	7.4— 8.1	6 16.7	2 11	15 20	4 22		18 7	
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	1 7	19 21	7 10		25 23	
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9	9 12	27 1	13 12		30 23	
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 00.0		28				
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	8 6	21 20	4 10		18 0	
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	2 18	22 13	4 18		17 23	
S Muscæ	12 07.4	—69 36	6.4— 7.3	9 15.8	9 8	28 15	7 7		26 14	
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	8 17	24 16	9 15		25 14	
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	7 2	20 13	9 17		23 5	
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	8 7	19 23	6 10		25 21	
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	6 19	20 21	8 15		22 17	
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5	9 22	27 4	13 11		30 17	
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	1 19	18 5	3 14		20 0	
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	3 8	17 9	7 11		21 12	
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	10 4	26 14	12 1		28 11	
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	10 21	21 20	7 8		23 19	
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	12 16	27 19	11 21		26 23	
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	8 3	20 23	12 5		27 1	
R Triang. Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	7 1	20 15	9 23		23 12	
S Triang. Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	5 17	24 16	6 8		25 7	
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	9 5	28 17	7 11		26 23	
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	11 0	28 17	6 14		24 7	
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	11 16	23 19	4 22		23 2	
X Sagittarii	17 41.3	—27 48	4.4— 5.0	7 00.3	9 5	23 5	6 6		20 6	
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9		16 7	2 10		19 13	
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	5 10	20 14	4 19		19 23	
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	11 8	22 22	9 5		20 18	
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	9 8	22 20	5 7		18 19	
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	6 6	26 23	6 8		27 0	
Y Lyræ	34.2	+43 52	11.3—12.3	0 12.1	7 9	25 12	6 13		24 15	
RZ Lyræ	18 39.9	+32 42	9.9—11.2	0 12.3	8 22	21 15	8 14		20 21	

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900		Decl. 1900		Magnitude	Approx. Period		Greenwich mean times of maxima in 1921							
								July				August			
	h	m	°	′		d	h	d	h	d	h	d	h	d	h
RT Scuti	18	44.1	−10	30	9.1— 9.7	0	11.9	8	18	20	16	7	12	19	10
κ Pavonis	18	46.6	−67	22	3.8— 5.2	9	02.2	4	9	22	13	9	18	27	22
U Aquilæ	19	24.0	− 7	15	6.2— 6.9	7	00.6	5	13	19	15	9	16	23	18
XZ Cygni		30.4	+56	10	8.6— 9.3	0	11.2	5	17	19	17	2	17	23	17
U Vulpec.		32.2	+20	07	6.5— 7.6	7	23.5	3	13	19	12	12	11	28	10
SU Cygni		40.8	+29	01	6.2— 7.0	3	20.3	7	13	22	22	7	7	22	16
η Aquilæ		47.4	+ 0	45	3.7— 4.5	7	04.2	8	3	22	11	12	23	27	8
S Sagittæ		51.5	+16	22	5.6— 6.4	8	09.2	8	23	25	18	11	12	28	6
X Vulpec.	19	53.3	+26	17	9.5—10.5	6	07.7	8	11	21	2	9	1	21	17
X Cygni	20	39.5	+35	14	6.0— 7.0	16	09.3	2	0	18	9	3	18	20	4
T Vulpec.		47.2	+27	52	5.5— 6.1	4	10.5	9	14	22	21	5	5	22	23
WY Cygni		52.3	+30	03	9.6—10.4	0	13.5	6	20	20	7	9	12	22	23
RV Capric.		55.9	−15	37	9.2—10.1	0	10.7	8	17	22	3	4	13	24	17
TX Cygni	20	56.4	+42	12	8.5— 9.7	14	17.4	3	10	18	4	1	21	31	8
VY Cygni	21	00.4	+39	34	8.8— 9.5	7	20.6	7	10	23	3	7	20	23	14
SW Aquarii		10.2	− 0	20	9.9—10.8	0	11.0	5	8	19	2	1	21	22	13
VZ Cygni	21	47.7	+42	40	8.2— 9.2	4	20.7	8	2	22	16	6	7	20	21
Y Lacertæ	22	05.2	+50	33	9.1— 9.6	4	07.8	4	11	21	18	8	1	25	8
δ Cephei		25.5	+57	54	3.7— 4.6	5	08.8	9	2	24	4	10	6	26	9
Z Lacertæ		36.9	+56	18	8.2— 9.0	10	21.1	10	20	21	17	1	14	23	9
RR Lacertæ		37.5	+55	55	8.5— 9.2	6	10.1	11	12	24	9	6	5	25	11
V Lacertae		44.5	+55	48	8.5— 9.5	4	23.6	10	0	24	23	8	22	18	21
X Lacertæ	22	45.0	+55	54	8.2— 8.6	5	10.7	10	2	26	10	6	8	22	16
SW Cassiop.	23	03.7	+58	11	9.2— 9.7	5	10.6	8	7	24	14	9	22	26	6
RS Cassiop.		32.6	+61	52	9.0—11.0	6	07.1	9	3	21	17	9	15	22	5
RY Cassiop.		47.2	+58	11	9.3—11.8	12	03.4	8	17	20	20	1	23	26	6
V Cephei	23	51.7	+82	38	6.0— 7.0	0	23.9	7	18	21	17	4	16	25	15

Monthly Report of the American Association of Variable Star Observers, March 20 to April 20, 1921.

The irregular variable R Coronae Borealis, 154428, has returned to its normal magnitude, but it is always well to keep it under observation. A mean light curve of its variations from December 1919 to April 1921 is published herewith.



SS Cygni has been at minimum for a longer stretch recently than ever before. R Scuti, *184205*, is again becoming available for observation and deserves closest attention. Messrs. Peltier are Lacchini are to be congratulated on their excellent lists, and many others are doing splendid work.

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
001726 T ANDROMEDAE—								
	2725.1	8.0 Ch,	2748.1	8.1 Ch.				
001755 T CASSIOPEIAE—								
	2750.3	7.7 Gi,	2756.3	7.6 L,	2763.3	7.7 Gi,	2766.4	7.8 L,
	2774.7	7.6 Bs,	2777.6	7.4 Pt,	2781.8	8.0 M.		
001838 R ANDROMEDAE—								
	2720.1	9.5 Ch,	2748.1	9.8 Ch,	2751.2	10.1 Pe.		
001909 S CETI—								
	2725.1	10.1 Ch.						
004047 U CASSIOPEIAE—								
	2774.6	11.5 Y,	2786.9	12.0 Pt.				
004746 RV CASSIOPEIAE—								
	2750.3	8.9 L,	2764.3	9.3 L,	2786.9	10.2 Pt.		
004958 W CASSIOPEIAE—								
	2750.3	8.7 Gi,	2766.4	8.8 Gi,	2777.6	9.9 Pt,	2779.5	9.9 Cg,
	2783.5	9.4 Gd,	2790.5	9.9 Cg.				
011272 S CASSIOPEIAE—								
	2756.4<12.6 Rk,		2773.4<12.3 Rk,		2780.4<10.1 Rk.			
012350 RZ PERSEI—								
	2774.6	10.4 Y.						
013238 RU ANDROMEDAE—								
	2719.1	11.5 Ch,	2745.1<11.5 Ch.					
013338 Y ANDROMEDAE—								
	2719.1<11.5 Ch,		2745.1	9.6 Ch,	2778.6	9.0 Pt.		
014958 X CASSIOPEIAE—								
	2777.6	11.7 Pt,	2778.6	10.3 Y.				
015354 U PERSEI—								
	2728.0<10.1 Jk,		2775.7	8.4 Mu,	2777.6	8.0 Pt.		
021024 R ARIÉTIS—								
	2754.3	11.6 L,	2756.9	10.5 Ym,	2760.3	10.5 Gi,	2766.3	10.8 L,
	2778.6	9.6 Pt.						
021258 T PERSEI—								
	2728.0	8.9 Jk,	2757.0	9.5 Jk.				
021403 o CETI—								
	2683.3	9.3 Bp,	2695.4	9.1 Bp_2,	2718.3	9.5 Bp_2,	2725.0	9.4 Ch,
	2730.3	9.2 Bp.	2738.3	9.2 Bp,	2744.0	9.3 Ch,	2745.3	8.9 Bp,
	2749.3	8.9 Bp_2,	2751.2	9.1 Pe,	2751.3	9.0 Bp_2,	2754.2	9.1 Pe,
	2757.0	10.1 Ym,	2757.3	9.1 L,	2765.3	8.6 Bp,	2766.3	9.0 L,
	2770.3	9.1 L.						
021558 S PERSEI—								
	2728.0	10.2 Jk,	2757.0	10.5 Jk.				
022000 R CETI—								
	2751.2	9.5 Pe.						
022150 RR PERSEI—								
	2771.6	11.3 Du,	2774.6	11.3 Y.				
022813 U CETI—								
	2720.1	9.2 Ch.						
023133 R TRIANGULI—								
	2728.0	9.5 Jk.	2760.5	7.9 Hs,	2763.0	7.7 Jk,	2765.6	9.6 Pw,
	2778.6	6.4 Pt.						
024356 W PERSEI—								
	2752.3	11.0 Pe.	2775.7	10.3 Mu,	2777.6	10.3 Pt,	2783.5	10.2 Gd,
	2792.6	10.7 Cl.						
030514 U ARIETIS—								
	2752.3	11.9 Gi,	2778.5	8.6 Y.				
031401 X CETI—								
	2758.3	9.1 L,	2772.3	9.1 L.				
032043 Y PERSEI—								
	2750.4	8.0 Pe.	2757.4	8.2 Pe,	2775.7	8.5 Mu,	2777.3	9.3 Pe,
	2777.6	8.6 Pt,	2792.6	9.7 Cl.				
032335 R PERSEI—								
	2750.4	12.1 Gi.						

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
032443 NOVA PERSEI—												
	2777.3	12.6	Pe.									
042209 R TAURI—												
	2779.5	<11.1	Pi,	2783.6	<10.6	Po,	2784.5	12.7	B.			
042215 W TAURI—												
	2751.2	9.2	Pe,	2754.3	9.2	Pe,	2760.5	10.0	Hs,	2760.6	10.2	Hl,
	2765.5	9.9	Hs,	2772.3	9.6	Pe,	2777.6	9.6	Pt,	2778.6	9.8	Pi,
	2778.6	9.6	Du,	2785.5	9.4	B.						
042309 S TAURI—												
	2779.5	<11.1	Pi,	2783.6	<10.6	Po.						
043065 T CAMELOPARDALIS—												
	2756.3	10.2	L,	2766.3	9.3	L,	2776.6	10.6	Bs,	2785.6	9.3	Pi.
043208 RX TAURI—												
	2779.5	<11.5	Pi,	2785.6	12.7	B.						
043274 X CAMELOPARDALIS—												
	2730.0	<11.1	Jk,	2757.0	<11.1	Jk,	2773.6	9.3	B,	2777.6	9.6	Pt,
	2778.6	9.5	Y,	2785.6	8.7	Pi,	2789.6	8.7	B.			
044617 V TAURI—												
	2765.5	11.0	Hs,	2770.6	11.8	B,	2778.6	12.3	Pt,	2780.6	10.9	Jd,
045307 R ORIONIS—												
	2744.7	<11.4	Mz,	2760.4	12.0	Gi,	2774.6	11.7	B,	2778.6	11.1	Y.
045514 R LEPORIS—												
	2721.0	9.2	Ch,	2745.1	9.1	Ch,	2754.3	7.9	L,	2759.8	9.4	Mz,
	2764.3	7.8	L,	2776.3	9.0	L,	2778.5	9.0	Ya,	2778.6	8.5	Pt,
	2787.6	8.0	B.									
050003 V ORIONIS—												
	2744.7	<11.2	Mz,	2766.5	10.9	B,	2778.6	10.2	Y,	2779.5	10.4	Pi,
	2780.6	9.9	Pt.									
050022 T LEPORIS—												
	2759.8	9.8	Mz,	2778.6	10.4	Pt,	2787.5	10.5	B.			
050953 R AURIGAE—												
	2771.6	<11.5	Pi,	2777.6	11.4	Pt,	2782.6	11.4	Lc,	2791.6	11.4	Lc.
052034 S AURIGAE—												
	2748.6	9.2	Hk,	2758.3	8.4	L,	2760.4	9.8	Pe,	2768.3	8.2	L,
	2771.2	9.1	Pe,	2772.3	8.4	L,	2777.3	9.0	Pe,	2778.6	9.1	Pi,
	2778.6	9.1	Ya,	2783.6	8.9	Gd,	2783.6	9.2	M,	2783.6	9.6	Po,
	2787.5	8.7	B.									
052036 W AURIGAE—												
	2758.3	<13.0	L.									
052404 S ORIONIS—												
	2744.7	<10.5	Mz,	2759.8	11.6	Mz,	2766.5	10.4	B,	2784.5	11.0	M,
	2792.5	11.1	Cl.									
053005a T ORIONIS—												
	2744.7	9.8	Mz,	2750.3	10.2	L,	2750.4	10.0	Pe,	2751.4	10.2	L,
	2754.4	10.4	L,	2756.3	10.4	L,	2758.3	10.4	L,	2759.8	10.1	Mz,
	2764.3	10.3	L,	2766.3	10.2	L,	2768.3	10.4	L,	2772.3	10.4	L,
	2777.6	10.5	Pt,	2778.6	10.7	Ya,	2779.6	10.0	Pi,	2783.5	10.4	Gd,
	2784.5	10.6	M,	2787.5	10.3	B.						
053068 S CAMELOPARDALIS—												
	2777.6	8.6	Pt,	2785.6	8.7	Pi.						
053326 RR TAURI—												
	2774.6	12.7	B.	2777.3	12.3	Ja,	2784.5	<11.5	M,	2792.5	<11.5	Cl.
053531 U AURIGAE—												
	2777.6	9.4	Pt,	2779.5	9.8	Y.	2779.6	9.3	B,	2783.5	9.3	Ya,
	2784.5	9.5	M.									
054319 SU TAURI—												
	2721.0	9.4	Ch,	2727.9	9.8	Jk,	2729.5	9.4	Cl,	2729.9	9.7	Jk,
	2744.0	9.5	Ch,	2750.2	9.5	Ch,	2750.3	9.4	L,	2751.3	10.0	Pe,
	2752.0	9.2	Ym,	2753.0	9.7	Ym,	2754.4	9.4	L,	3756.3	9.6	L,
	2756.4	9.4	Rk,	2757.0	9.7	Ym,	2757.0	9.5	Jk,	2759.1	9.7	Ym,
	2761.1	9.7	Ym,	2762.9	9.7	Jk,	2764.3	9.7	L,	2770.6	9.5	B,
	2771.0	9.7	Ym,	2771.6	9.7	Pt,	2772.3	9.9	L,	2774.4	9.6	Rk,

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
	2774.5	9.5 Y,	2775.6	9.6 Pt,	2776.3	9.4 L,	2777.6	9.7 Pt,
	2778.0	9.4 Ym,	2778.5	9.6 Y,	2778.6	9.5 Pi,	2778.6	9.5 Pt,
	2779.0	10.0 Ym,	2779.6	9.4 B,	2780.4	9.5 Rk,	2780.6	9.5 Pt,
	2781.6	9.5 Pt,	2782.6	9.4 Pt,	2784.5	9.4 M,	2789.6	9.4 B,
	2789.6	9.8 Cl,	2790.6	9.5 Pt,	2792.6	9.8 Cl.		
054615a Z TAURI—								
	2774.5<13.0 Y.							
054615b RS TAURI—								
	2774.5	11.0 Y.						
054615c RU TAURI—								
	2774.5	9.2 Y.						
054920 U ORIONIS—								
	2721.0	11.3 Ch,	2744.1<11.2 Mz,		2747.8	11.6 Ml,	2750.2	12.3 Ch,
	2751.2<11.6 Pe,		2766.6	10.9 B,	2778.6	10.9 Pt,	2778.6	11.3 Pi,
	2779.6 <9.7 Jd,		2782.6	10.1 Su,	2784.5	10.9 M,	2790.5 <9.9 Cg.	
054974 V CAMELOPARDALIS—								
	2750.4<14.0 Gi,		2770.6<12.5 B,		2778.6	9.8 Y,	2787.6<13.5 B.	
055353 Z AURIGAE—								
	2760.5	10.8 Hs,	2765.5	10.8 Hs,	2771.6	10.2 Pi,	2778.6	9.9 Pi.
	2778.6	9.9 Pt,	2773.5	10.2 B,	2783.6	9.6 M.		
060450 X AURIGAE—								
	2765.5	10.7 Hs,	2774.6	10.1 B,	2776.5	10.1 Ro,	2777.5	9.9 Ro,
	2778.6	10.3 Pt,	2782.6	10.2 Po,	2783.5	9.8 Ro,	2783.6	10.2 M,
	2786.5	9.6 Ro,	2794.5	9.6 Ro.				
060547 SS AURIGAE—								
	2718.1<11.8 Ch,		2725.9<11.4 Jk,		2727.9<11.4 Jk,		2729.9<11.0 Jk,	
	2750.2<11.8 Ch,		2750.4<13.3 Ja,		2750.4<13.9 Gi,		2751.4<13.9 Gi.	
	2751.4<14.5 L,		2752.0<12.4 Ym,		2752.4<13.9 Gi,		2753.0<12.4 Ym,	
	2754.3<13.9 Gi,		2754.4<14.0 L,		2756.1<13.9 Ym,		2756.3<14.5 L,	
	2756.9<10.8 Jk,		2757.1<13.9 Ym,		2757.4<12.6 Pe,		2758.3	14.5 L,
	2759.1<13.9 Ym,		2759.4	14.5 L,	2761.0<12.4 Ym,		2762.4<13.3 Ja,	
	2763.0<10.8 Jk,		2763.4<14.0 L,		2764.0<13.3 Ym,		2764.3<13.3 L,	
	2765.3<13.8 Gi,		2765.4<13.8 L,		2766.3<13.3 L,		2766.4<13.8 Gi,	
	2767.1<12.4 Ym,		2767.3<13.3 Gi,		2767.4<12.6 L,		2768.3<12.9 L.	
	2770.5<11.6 Ja,		2771.0<12.4 Ym,		2771.4<12.7 L,		2771.5<10.8 Cl,	
	2771.6<12.4 Pt,		2771.6<11.4 Pi,		2771.6	10.8 Pw,	2772.3<13.0 L,	
	2772.4<13.0 Gi,		2773.4<12.7 L,		2774.5<11.5 Cl,		2774.5<13.3 Y,	
	2775.6<12.4 Pt,		2776.3<13.3 L,		2777.3<13.3 Ja,		2777.4<12.6 Pe,	
	2777.6<12.6 Pt,		2778.0<13.9 Ym,		2778.6<13.3 Y,		2778.6<12.6 Pt,	
	2779.0<13.3 Ym,		2779.5<13.3 Y,		2780.4<13.3 Ja,		2780.6<12.6 Pt,	
	2781.6<12.6 Pt,		2782.6<12.6 Pt,		2783.6<12.6 Pt,		2783.6<12.4 M,	
	2784.6<12.6 Pt,		2785.6<12.6 Pt,		2789.6<12.5 Cl,		2789.6<13.8 B,	
	2790.6<12.6 Pt,		2791.6<12.4 Pi,		2791.7<12.6 Pt,		2793.5<11.0 Cl.	
061647 V AURIGAE—								
	2774.6	11.7 B.						
061702 V MONOCEROTIS—								
	2778.6	12.1 Pt,	2784.6	9.2 M.				
063159 U LYNCIS—								
	2778.6	12.9 Y,	2791.6<12.9 Pi.					
063308 R MONOCEROTIS—								
	2789.6	12.2 B,	2792.6	11.9 B.				
063558 S LYNCIS—								
	2791.6<12.6 Pi.							
064030 X GEMINORUM—								
	2778.6	13.0 Pi.						
064707 W MONOCEROTIS—								
	2770.6	9.5 B,	2777.6	11.2 Pt,	2778.6	10.9 Ya,	2789.6	9.8 B.
064932 NOVA GEMINORUM #2—								
	2754.4	14.1 L,	2782.6<11.3 Po.					
065111 Y MONOCEROTIS—								
	2771.6<11.7 Pw,		2778.5<13.0 Pi,		2778.6	13.4 Y.		

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
065208 X MONOCEROTIS—												
	2754.4	8.1	L,	2766.3	8.6	L,	2778.6	8.7	Ya,	2779.6	7.2	Hk.
065355 R LYNCIS—												
	2763.5	10.6	Gi,	2771.6	10.5	Pi,	2778.6	10.4	Y,	2784.6	10.5	M,
	2792.6	9.4	B.									
070109 V CANIS MINORIS—												
	2730.0	10.3	Jk,	2760.5	<12.0	Hs,	2784.6	<11.7	M.			
070122a R GEMINORUM—												
	2718.1	9.2	Ch,	2730.0	9.6	Jk,	2744.7	9.8	Mz,	2750.2	10.6	Ch,
	2750.4	11.2	Pe,	2759.4	11.0	Pe,	2776.6	10.9	Ml,	2777.4	11.2	Pe,
	2777.6	11.4	Pt,	2784.6	11.4	M						
070122b Z GEMINORUM—												
	2730.0	<11.1	Jk,	2744.7	<11.1	Mz,	2750.2	11.3	Ch,	2750.4	12.3	Pe,
	2777.4	12.0	Pe,	2777.6	12.4	Pt,	2784.6	12.0	M.			
070122c TW GEMINORUM—												
	2730.0	8.6	Jk,	2744.7	8.4	Mz,	2750.4	7.7	Pe,	2759.4	7.9	Pe,
	2777.4	7.8	Pe,	2784.6	8.4	M						
070310 R CANIS MINORIS—												
	2730.0	8.2	Jk,	2758.3	8.3	L,	2763.0	8.5	Jk,	2772.3	8.2	L,
	2778.5	8.8	Pi,	2783.6	8.8	Ya,	2784.6	8.8	M,	2787.6	8.6	B.
071044 L_2 PUPPIS—												
	2719.1	4.3	Ch.									
071713 V GEMINORUM—												
	2744.7	<11.4	Mz,	2778.5	11.5	Pi.						
072708 S CANIS MINORIS—												
	2718.1	<11.5	Ch,	2730.0	<10.8	Jk,	2750.2	<11.5	Ch,	2750.4	11.9	Pe,
	2756.4	<10.0	Rk,	2757.4	11.9	Pe,	2758.3	11.3	L,	2760.4	11.1	Pe,
	2772.3	10.4	L,	2772.4	10.2	Pe,	2772.5	10.1	Ro,	2772.6	<10.8	Jd,
	2775.5	9.9	Ro,	2776.5	9.7	Ro,	2776.6	9.7	O,	2777.4	9.9	Pe,
	2778.4	9.8	Rk,	2778.6	10.1	Cd,	2780.4	9.8	Rk,	2781.5	9.9	Cd,
	2781.5	10.3	Pi,	2781.6	9.7	B,	2782.6	10.1	Su,	2782.6	9.8	Po,
	2783.5	9.6	Ro,	2783.6	10.3	M,	2786.5	9.5	Ro,	2790.6	9.5	Pt,
	2792.7	9.5	Po,	2792.7	9.6	Cd,	2793.5	9.5	Ro.			
072811 T CANIS MINORIS—												
	2780.6	10.0	Pt,	2780.6	9.4	Jd,	2783.6	9.8	M,	2792.6	10.3	B.
073508 U CANIS MINORIS—												
	2758.3	13.0	L,	2774.5	13.2	Y,	2776.3	<13.0	L,	2781.5	<12.4	Pi.
073723 S GEMINORUM—												
	2744.7	10.2	Mz,	2765.5	9.5	Hs,	2777.4	8.7	Pe,	2777.7	9.1	Pt,
	2778.5	9.2	Pi,	2780.3	9.2	Pe,	2781.6	8.8	B,	2782.7	9.0	Po,
	2783.6	9.3	M.									
074323 T GEMINORUM—												
	2744.7	9.9	Mz,	2776.6	9.1	Ml,	2778 5	9.5	Pi,	2782.7	9.0	Po,
	2783.6	9.3	M,	2783.6	9.1	Ya.						
074922 U GEMINORUM—												
	2718.1	<12.3	Ch,	2728.0	<10.9	Jk,	2729.9	<11.4	Jk,	2744.7	10.9	Mz,
	2750.2	<12.3	Ch,	2750.4	<13.7	Ja,	2750.3	14.1	L,	2750.4	<13.7	Gi,
	2751.4	13.6	L,	2751.4	14.0	Gi,	2752.3	<13.7	L,	2752.4	14.0	Gi,
	2753.4	<13.3	L,	2754.3	14.0	Gi,	2754.4	<13.7	L,	2756.0	<13.7	Ym,
	2756.3	14.0	L,	2756.9	<10.9	Jk,	2757.0	<13.7	Ym,	2758.3	<13.7	L.
	2759.1	14.0	Ym,	2759.4	<13.7	L,	2762.4	<13.7	Ja,	2762.9	<10.4	Jk,
	2763.4	<13.7	L,	2763.4	<12.3	Rk,	2763.4	14.0	Gi,	2764.3	<13.7	L,
	2764.4	13.8	L,	2765.3	12.9	Gi,	2765.4	12.8	L,	2766.3	9.2	L,
	2766.4	9.7	Gi,	2767.3	9.8	Gi,	2767.4	9.3	L,	2768.3	9.0	L,
	2770.4	9.8	Gi,	2771.4	9.1	L,	2771.6	9.3	Pi,	2771.6	9.3	Pt,
	2771.6	9.6	Du,	2772.3	9.0	L,	2772.4	9.9	Gi,	2772.7	9.7	Du,
	2773.4	9.1	L,	2774.5	9.5	Y,	2775.6	10.2	Pt,	2776.3	10.8	L,
	2777.4	11.7	Ja,	2777.6	11.5	Pt,	2778.0	12.4	Ym,	2778.4	12.3	Rk,
	2778.5	12.6	Pi,	2778.6	12.6	Pt,	2778.6	12.5	Y,	2778.7	<10.5	Du,
	2779.0	12.9	Ym,	2779.6	<11.7	Jd,	2779.6	13.3	Y,	2779.6	13.3	Du,
	2780.3	11.4	Pe,	2780.4	13.5	Ja,	2780.4	<12.3	Rk,	2780.6	13.9	Pt,

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
074922 U GEMINORUM—												
	2781.6	<13.3	Pt,	2782.6	<13.3	Pt,	2783.6	<14.1	Pt,	2783.6	<12.4	M,
	2784.6	<13.3	Pt,	2785.6	<12.4	Pt,	2789.6	14.0	B,	2790.6	<13.3	Pt,
	2791.7	<13.3	Pt,	2792.6	<13.0	Du.						
081112 R CANCRI—												
	2719.1	<10.2	Ch,	2744.1	8.8	Ch,	2751.7	8.8	Ml,	2754.3	8.6	L,
	2765.4	7.6	Rk,	2766.3	7.8	L,	2771.6	7.9	Pi,	2773.4	7.4	Rk,
	2777.7	7.4	Pt,	2778.4	7.5	Rk,	2779.5	7.8	Cg,	2779.7	7.7	Du,
	2783.7	7.7	Po,	2784.6	8.9	Ya,	2784.6	8.2	M,	2790.5	7.6	Cg,
	2791.6	8.1	B,	2792.7	7.9	Du.						
081617 V CANCRI—												
	2752.4	9.3	Gi,	2753.0	9.4	Ym,	2762.4	9.0	Ja,	2765.3	8.9	Gi,
	2765.5	8.8	Hs,	2771.6	8.8	Pi,	2776.6	9.4	Ml,	2777.3	8.3	Ja,
	2777.7	8.0	Pt,	2778.6	8.0	Du,	2782.7	8.2	Po,	2783.6	8.1	M,
	2786.6	7.8	Ya,	2791.6	7.7	B,	2792.6	7.8	Du.			
082405 RT HYDRAE—												
	2758.4	8.3	L,	2772.3	8.5	L.						
083019 U CANCRI—												
	2771.6	<11.3	Pi.									
083350 X URSAE MAJORIS—												
	2767.6	8.8	Pw,	2768.6	9.3	B,	2771.6	9.4	Pi,	2776.6	9.5	Ml,
	2779.7	9.4	Du,	2782.8	9.1	M,	2786.6	9.6	Ya,	2791.7	9.3	Cg,
	2791.8	9.4	Pt.									
084803 S HYDRAE—												
	2720.1	<11.0	Ch,	2748.1	<11.0	Ch,	2777.5	11.9	Ro,	2781.6	13.0	Pi,
	2784.5	<11.0	Ya,	2786.5	11.5	Ro.						
084917 X CANCRI—												
	2752.0	7.0	Ym,	2756.0	7.1	Ym.						
085008 T HYDRAE—												
	2720.1	<11.0	Ch,	2746.1	<11.0	Ch,	2781.6	11.0	Pi.			
085120 T CANCRI—												
	2754.3	8.0	L,	2765.5	8.9	Hs,	2766.3	7.9	L,	2777.7	8.2	Pt,
	2784.6	8.8	M,	2786.6	8.4	Ya.						
090024 S PYXIDIS—												
	2783.6	11.8	Pt.									
090151 V URSAE MAJORIS—												
	2751.3	9.9	Pe,	2784.6	10.3	M.						
090425 W CANCRI—												
	2756.0	12.0	Ym,	2758.3	12.0	L,	2765.5	12.1	Hs,	2766.6	12.0	B,
	2776.3	12.9	L.									
093014 X HYDRAE—												
	2775.6	9.5	Mu,	2781.6	9.6	Po,	2781.6	9.6	Pi,	2784.5	9.5	Ya,
	2791.6	9.6	B.									
093178 Y DRACONIS—												
	2771.6	<11.0	Du,	2779.5	<13.9	Y,	2785.6	<12.0	Pi.			
093934 R LEONIS MINORIS—												
	2720.1	8.7	Ch,	2734.1	8.3	Ch,	2744.1	7.7	Ch,	2749.1	7.7	Ch,
	2758.3	7.5	L,	2765.6	8.4	Pw,	2772.3	7.6	L,	2773.6	7.7	B,
	2777.7	8.0	Pt,	2777.8	7.2	Ro,	2778.6	8.4	Pw,	2779.6	8.8	Jd,
	2783.6	8.2	Jd,	2786.6	7.9	Ya.						
094211 R LEONIS—												
	2606.6	9.0	Bp,	2616.7	8.7	Bp,	2620.7	8.7	Bp_2,	2625.6	8.8	Bp_2,
	2630.6	8.7	Bp,	2636.7	8.5	Bp,	2637.7	8.3	Bp,	2645.7	8.6	Bp,
	2654.6	8.5	Bp,	2659.7	8.3	Bp,	2667.7	7.4	Bp,	2695.5	6.0	Bp_2,
	2699.4	6.1	Bp_2,	2718.4	6.3	Bp,	2720.1	6.2	Ch,	2725.7	6.7	Bp,
	2734.7	6.6	Bp,	2748.4	7.2	Bp,	2749.1	7.0	Ch,	2756.1	7.9	Ym,
	2756.4	6.7	Rk,	2758.5	7.6	Bp,	2761.4	7.0	Rk,	2762.4	7.7	Pe,
	2763.4	6.9	Rk,	2764.4	7.8	Bp,	2765.4	6.8	Rk,	2765.5	7.8	Hs,
	2771.6	8.3	Pw,	2772.4	7.3	Rk,	2772.5	7.1	Ro,	2772.6	7.4	Hk,
	2772.8	6.9	Bs,	2774.5	8.0	O,	2775.6	7.4	Mu,	2776.5	7.3	Ro,
	2777.4	8.6	Pe,	2777.5	7.5	Ro,	2777.7	7.3	Pt,	2778.4	7.7	Rk,
	2778.6	8.2	Pw,	2778.7	8.3	Hk,	2779.6	8.8	Cg,	2781.4	8.1	Bp_2,
	2781.6	8.1	Po,	2781.6	8.1	Pw,	2782.6	8.6	Su,	2783.5	7.8	Ro,

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
094211 R LEONIS—												
	2783.6	7.8	M,	2786.5	8.0	Ro,	2786.6	8.5	Ya,	2789.6	7.9	Cl,
	2790.6	9.0	Cg,	2792.6	8.6	Hm,	2792.6	8.5	Hs,	2793.5	8.5	Ro.
094512 X LEONIS—												
	2763.5	10.6	Gi,	2771.6	10.5	Pi,	2778.6	10.4	Y,	2784.6	10.5	M,
	2758.3<13.0		L,	2763.4	12.3	L,	2764.3	12.2	L,	2765.4	12.7	L,
	2776.3<13.0		L.									
094622 Y HYDRAE—												
	2777.7	6.6	Pt,	2781.6	7.0	Pi,	2784.6	7.3	Ya.			
095421 V LEONIS—												
	2757.5	8.5	Ja,	2762.4	8.5	Ja,	2762.4	9.1	Pe,	2765.4	9.0	Pe,
	2765.5	8.9	Hs,	2765.6	8.7	Pw,	2770.5	8.7	Ja,	2777.3	9.2	Ja,
	2777.4	9.3	Pe,	2777.7	9.0	Pt,	2783.6	9.2	M,	2791.6	9.3	B,
	2792.6	9.9	Hs,	2792.6	10.0	Hm.						
103212 U HYDRAE—												
	2758.4	5.2	L,	2772.3	5.0	L,	2777.4	5.0	Pe.			
103769 R URSAE MAJORIS—												
	2721.2	9.8	Ch,	2746.1	10.8	Ch,	2769.6<11.5		M,	2771.6<10.0		Pw,
	2778.6	10.3	Pw,	2778.6	12.2	Pt,	2781.8<11.0		Po,	2784.6	12.2	B,
	2785.6	12.2	Pi,	2786.6<11.0		Ya,	2793.5 <9.0		Cl.			
104620 V HYDRAE—												
	2721.2	8.2	Ch,	2749.1	8.2	Ch,	2758.4	7.1	L,	2772.3	6.7	L,
	2777.7	7.0	Pt,	2781.6	8.0	Pi,	2781.7	8.1	Po,	2784.6	8.2	Ya.
104814 W LEONIS—												
	2756.1	10.5	Ym,	2757.0	10.7	Ym,	2773.6	11.8	B,	2779.5	11.4	Y,
	2780.6	11.7	Pt,	2783.6<11.9		M,	2785.6	10.8	Pw.			
110506 S LEONIS—												
	2778.6	11.9	Du,	2779.6	11.9	Du,	2780.6	11.8	Pt,	2781.6	12.0	B,
	2781.6	12.2	Pi,	2784.6	11.5	M,	2785.6	10.3	Pw,	2792.6	12.6	Du,
115919 R COMAE BERENICES—												
	2780.6<13.0		Ja,	2781.6<13.0		Pw,	2792.6	12.5	B.	2792.6<11.8		Ya.
120012 SU VIRGINIS—												
	2723.1<12.5		Ym,	2756.1<12.5		Ym,	2777.3<12.5		Ja,	2778.1<12.5		Ym,
	2785.6<12.0		Pw.									
120905 T VIRGINIS—												
	2781.6<12.1		Pi.	2785.6<12.0		Pw.						
121418 R CORVI—												
	2750.5	11.4	Ja,	2777.5	10.5	Ja.	2777.7	10 5	Pt,	2781.6	10.4	Pi,
	2791.6	10.0	Pw.									
122001 SS VIRGINIS—												
	2640.7	7.1	Bp,	2647.7	7.4	Bp_2,	2648 7	6.9	Bp,	2654.6	7.2	Bp_2,
	2659.6	7.1	Bp_2,	2666.6	7.4	Bp,	2667.6	7.6	Bp,	2695.7	7.4	Bp.
	2725.7	7.9	Bp.	2734.7	8.5	Bp,	2736.4	8.3	Bp_2,	2749.4	8.1	Bp,
	2751.4	8.4	Bp_2,	2758.4	7.3	L,	2767.3	8.5	Bp,	2776.3	8.0	L,
	2779.4	8.9	Bp.	2781.4	8.8	Bp,	2782.8	8.7	M.	2792.5	8.6	Ya.
122532 T CANUM VENATICORUM—												
	2774.7	9.8	Bs,	2777.7	9.7	Pt,	2785.6	10.5	Pi,	2785.8	9.7	M.
	2791.6	10.3	Pw,	2792.6	10.5	Ya.						
122803 Y VIRGINIS—												
	2781.7<11.4		Po,	2791.6	10.3	Pw.						
123160 T URSAE MAJORIS—												
	2721.2	11.7	Ch,	2735.5	10.0	Ch,	2749.2	9.2	Ch,	2751.3	8.6	Pe,
	2753.1	8.3	Ym,	2766 0	7.9	Ym,	2759.4	8.2	Pe,	2764.0	7.7	Ym,
	2765.4	7.7	Pe,	2769.8	7.8	M,	2771.7	7.5	Cd,	2772.3	7.1	Pe,
	2772.6	7.3	Jd,	2772.7	7.5	Bs,	2774.5	7.0	O,	2775.5	7.3	Ro,
	2775.6	7.3	Jd,	2775.7	7.0	Mu,	2775.9	7.4	Ml,	2776.5	7.1	Ro,
	2777.7	7.5	Pt,	2778.0	7.5	Ym,	2782.7	7.3	Po,	2783.5	6.9	Ro,
	2783.6	7.6	Cg,	2783.6	7.6	Gd,	2784.6	6.8	B,	2785.6	7.1	Pi,
	2785.7	7.6	Su,	2785.8	6.4	M,	2786.5	6.8	Ro,	2791.6	9.1	Pw,
	2793.5	6.8	Ro,	2797.9	7.4	Cd.						

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
123307 R VIRGINIS—												
	2747.9	10.3	Ml,	2753.4	7.7	L,	2757.4	7.8	Pe,	2762.3	7.4	Pe,
	2764.7	7.8	Lc,	2765.4	7.4	Pe,	2766.3	7.0	L,	2766.4	7.1	Pe,
	2772.3	6.8	L,	2777.4	7.1	Pe,	2777.7	7.0	Pt,	2779.6	7.8	Lc,
	2780.3	7.0	Pe,	2781.6	7.0	Cg,	2781.7	7.4	Po,	2782.8	7.0	M,
	2784.7	7.6	Lc,	2791.7	7.6	Lc,	2792.6	7.6	Ya.			
123459 RS URSAE MAJORIS—												
	2721.2	10.4	Ch,	2735.5	11.2	Ch,	2749.2	<11.2	Ch,	2753.1	12.6	Ym,
	2756.0	12.6	Ym,	2764.0	12.6	Ym,	2769.8	<11.5	M,	2771.0	<12.6	Ym,
	2775.7	<10.6	Mu,	2777.7	13.4	Pt,	2778.0	13.4	Ym,	2782.7	<10.8	Po,
	2784.6	<13.5	B,	2785.6	<11.8	Pi.						
123961 S URSAE MAJORIS—												
	2721.2	8.9	Ch,	2735.5	9.9	Ch,	2749.2	10.0	Ch,	2751.3	10.2	Pe,
	2753.4	10.1	L,	2759 4	10.5	Pe,	2765.4	10.5	Pe,	2766.4	10.7	L,
	2769.7	11.1	M,	2772.6	10.0	Jd,	2775.7	10.8	Mu,	2777.7	11.3	Pt,
	2779.6	10.5	Jd,	2782.7	10.8	Po,	2783.5	11.6	Ro,	2783.6	11.2	Gd,
	2783.6	<9.2	Cg,	2784.6	11.6	B,	2785.6	11.1	Pi.	2785.8	11.3	M,
	2786.5	11.5	Ro,	2792.6	11.9	Hs,	2793.5	11.3	Ro.			
124204 RU VIRGINIS—												
	2762.4	13.0	Ja,	2777.5	<12.8	Ja,	2795.6	<10.0	Pw.			
124606 U VIRGINIS—												
	2757.4	<12.2	Pe,	2762.4	11.9	Ja,	2765.3	<10.4	Pe,	2777.4	11.6	Pe,
	2780.4	10.6	Ja,	2781.3	10.6	Pe,	2783.8	10.2	Pt.			
130212 RV VIRGINIS—												
	2756.1	11.3	Ym,	2778.2	12.0	Ym,	2780.8	12.0	Pt.			
132002 W VIRGINIS—												
	2792.6	9.5	Ya.									
132202 V VIRGINIS—												
	2792.6	<10.6	Ya.									
132422 R HYDRAE—												
	2730.4	7.0	Ch,	2749.2	<7.3	Ch,	2750.6	7.2	L,	2753.7	7.8	Gi,
	2764.6	7.8	L,	2777.7	8.7	Pt,	2782.7	9.1	Lc,	2791.7	9.2	Lc.
132706 S VIRGINIS—												
	2730.4	6.8	Ch,	2748.2	4.9	Ch,	2775.7	8.0	Mu,	2777.7	7.5	Pt,
	2778.1	8.0	Ym,	2779.6	9.0	Jd,	2780.7	7.9	Bs,	2782.8	8.0	M,
	2792.6	7.9	Cg,	2792.6	8.4	Ya.						
133273 T URSAE MINORIS—												
	2767.6	<12.3	Du,	2785.6	<12.1	Pi.						
134440 R CANUM VENATICORUM—												
	2751.9	9.3	Ml,	2769.7	8.4	M,	2774.7	8.8	Bs,	2776.5	9.2	O,
	2777.7	8.9	Pt,	2778.5	9.1	Ro,	2782.8	9.0	Po,	2785.8	8.7	M,
	2791.6	8.5	Pi,	2792.6	8.6	Ya,	2792.6	8.5	Y.			
140113 Z BOOTIS—												
	2782.8	9.5	M,	2792.6	11.4	Y.						
141567 U URSAE MINORIS—												
	2730.4	10.7	Ch,	2751.2	9.2	Ch,	2767.6	9.7	Du,	2777.7	9.6	Pt,
	2782.8	9.1	Po,	2784.6	9.3	M,	2785.6	9.0	Pi,	2794.5	9.5	Ro.
141954 S BOOTIS—												
	2730.4	8.2	Ch,	2751.2	9.2	Ch,	2753.7	9.1	Gi,	2754.3	9.4	L,
	2756.0	10.1	Ym,	2766.4	10.0	L,	2766.5	9.8	Gi,	2767.1	9.7	Ym,
	2769 7	10.0	M,	2777.7	10.1	Pt,	2778.0	10.3	Ym,	2792.6	11.0	Cl,
	2781.7	10.4	Po,	2791.6	11.0	Pi.						
142205 RS VIRGINIS—												
	2757.5	9.7	Ja,	2780.5	8.8	Ja,	2785.8	8.3	M.			
142539 V BOOTIS—												
	2758.4	9.9	L,	2759 6	9.9	O,	2769.7	9.8	M,	2772.3	10.1	L,
	2775.7	10.5	Mu,	2777.5	9.9	Ro,	2777.7	10.6	Pt,	2781.7	10.3	Po,
	2783.5	10.3	Ro,	2791.6	10.1	Pi.						
142584 R CAMELOPARDALIS—												
	2763.4	12.8	Gi,	2785.6	10.5	Pi.						

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
143227 R BOOTIS—												
	2730.4	<11.3	Ch.	2756.1	10.9	Ym,	2759.4	10.4	Pe,	2763.8	9.2	M,
	2777.7	8.7	Pt,	2778.1	8.8	Ym,	2781.7	8.6	Po,	2785.6	8.6	Pi.
144918 U BOOTIS—												
	2754.6	11.0	Gi,	2766.4	11.6	Gi,	2785.6	12.0	Pi,	2790.8	12.0	M.
155018 RT LIBRAE—												
	2756.2	<12.9	Ym.									
150519 T LIBRAE—												
	2756.2	12.9	Ym,	2783.8	11.7	Pt.						
150605 Y LIBRAE—												
	2750.7	13.2	L,	2764.6	13.0	L,	2783.8	11.1	Pt.			
151520 S LIBRAE—												
	2734.4	9.5	Ch,	2758.6	9.3	L,	2772.7	8.9	L,	2783.8	8.4	Pt.
151714 S SERPENTIS—												
	2750.5	12.8	Ja,	2756.6	<12.7	L,	2766.6	<13.5	L,	2780.5	<13.0	Ja.
	2790.9	11.3	M.									
151731 S CORONAE BOREALIS—												
	2730.4	7.7	Ch,	2751.3	7.8	Ch,	2760.4	12.1	Pe,	2765.4	12.2	Pe,
	2769.7	8.5	M,	2771.6	8.6	Cd,	2777.7	9.1	Pt,	2778.2	9.4	Ym,
	2778.6	8.9	Cd,	2781.6	9.5	Su,	2781.6	9.3	Cd,	2782.8	9.1	Po,
	2785.6	9.3	Pi,	2790.9	9.7	M,	2792.6	9.9	Hs,	2792.6	9.2	Y,
	2792.7	9.5	Cd.									
151822 RS LIBRAE—												
	2750.6	7.6	L,	2764.6	7.9	L.						
153378 S URSAE MINORIS—												
	2752.0	11.7	Ym,	2753.0	11.7	Ym,	2756.0	11.6	Ym,	2775.7	11.1	Mu,
	2777.6	10.7	Ro,	2778.6	10.9	Su,	2780.6	11.2	Pt,	2781.8	11.2	Po,
	2783.6	11.2	Ro,	2785.6	11.4	Pi,	2786.6	11.2	Ro,	2798.8	11.3	M.
154428 R CORONAE BOREALIS—												
	2730.4	6.1	Ch,	2749.2	6.3	Ch,	2750.3	6.7	Ch,	2750.4	7.0	Pe,
	2750.6	7.2	L,	2751.3	7.0	Ch,	2751.4	7.0	Pe,	2751.4	7.3	L,
	2753.3	7.0	Ym,	2753.4	7.1	L,	2754.4	7.2	L,	2754.6	7.6	Ja,
	2756.2	7.0	Ym,	2756.6	7.7	L,	2757.4	7.4	Pe,	2757.5	7.5	Ja,
	2757.7	7.6	L,	2758.7	7.8	L,	2759.4	7.4	Pe,	2760.4	7.5	Pe,
	2762.4	8.0	Ja,	2763.4	8.3	L,	2763.5	8.5	Gi,	2765.4	8.9	L,
	2765.4	8.3	Pe,	2766.4	8.7	Pe,	2766.5	8.7	Gi,	2766.6	8.8	L,
	2767.2	9.5	Ym,	2767.4	9.2	L,	2769.7	9.5	M,	2770.5	9.3	Ja,
	2771.4	9.2	L,	2771.6	8.9	Du,	2771.6	8.6	Pt,	2771.7	8.9	Hk,
	2771.8	8.8	M,	2772.7	8.5	Du,	2772.7	8.9	L,	2773.4	8.0	L,
	2774.4	7.6	Mt,	2774.8	8.2	M,	2776.3	7.7	L,	2776.7	7.0	Mu,
	2777.4	7.4	Pe,	2777.5	7.4	Ja,	2777.7	7.0	Pt,	2778.2	7.6	Ym,
	2778.6	7.4	Pi,	2778.6	7.9	Y,	2778.6	7.3	Hk,	2778.6	6.5	Pt,
	2778.7	7.0	Po,	2778.8	6.9	M,	2779.5	6.9	Cl,	2779.6	7.2	Hk,
	2779.7	7.0	Mu,	2780.4	6.9	Pe,	2780.6	6.8	Ja,	2780.6	6.5	Pt,
	2780.7	6.9	L,	2780.7	6.9	Mu,	2781.6	7.1	Pi,	2781.6	6.5	Pt,
	2781.8	6.8	Po,	2781.8	6.4	M,	2782.6	6.4	Pt,	2782.8	6.8	Po,
	2782.8	6.4	M,	2783.6	6.4	Pt,	2783.6	6.4	M,	2784.6	6.3	Pt,
	2784.7	6.3	M,	2784.7	6.7	Mu,	2785.6	6.8	Pi,	2785.7	6.2	Pt,
	2785.7	6.1	Su,	2785.7	6.8	Mu,	2785.8	6.2	M,	2786.7	6.3	Pt,
	2786.7	6.7	Ya,	2787.8	6.3	M,	2788.7	6.6	Mu,	2789.6	6.7	Cl,
	2789.6	6.7	Y,	2790.6	6.1	Pt,	2790.9	6.2	M,	2791.6	6.2	Pi,
	2791.7	6.2	Pt,	2792.6	6.4	Cg,	2792.6	6.6	Hs,	2792.6	6.7	Cl,
	2792.6	6.5	Y,	2792.7	6.3	Po,	2792.7	6.2	Du,	2793.8	6.7	Mu,
	2795.8	6.4	Bs,	2797.9	6.2	Pt,	2798.8	6.0	M.			
154536 X CORONAE BOREALIS—												
	2781.8	11.4	M.									
154615 R SERPENTIS—												
	2754.6	7.7	Ja,	2766.4	8.2	Pe,	2777.5	7.8	Ja,	2780.8	8.1	Pt,
	2781.8	8.1	M,	2782.7	7.4	Su,	2782.8	8.0	Po.			
154639 V CORONAE BOREALIS—												
	2769.7	9.7	M,	2780.6	10.0	Pt.	2791.6	10.3	Pi.	2792.6	10.4	Hs.

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.	J.D.	Est.Obs.
154715 R LIBRAE—								
	2783.8	11.2 Pt,	2790.8	<11.6 M.				
155018 RR LIBRAE—								
	2734.4	9.5 Ch,	2750.6	11.1 L,	2756.2	11.2 Ym,	2764.6	11.8 L,
	2783.8	12.5 Pt.						
155229 Z CORONAE BOREALIS—								
	2753.3	12.8 Ym,	2756.1	13.1 Ym,	2778.1	<13.6 Ym.		
160021 Z SCORPII—								
	2756.7	10.4 L,	2766.7	10.7 L.				
160118 R HERCULIS—								
	2780.6	13.5 Ja.						
160210 U SERPENTIS—								
	2753.3	11.5 Ym,	2774.8	11.3 M,	2780.8	10.6 Pt.		
161122a R SCORPII—								
	2757.7	11.8 Ja,	2780.6	11.1 Ja,	2780.8	11.9 Pt,	2790.8	12.4 M.
161122b S SCORPII—								
	2780.6	10.8 Ja,	2780.8	11.4 Pt,	2790.8	10.3 M.		
161122c T SCORPII—								
	2780.8	10.3 Pt,	2790.8	11.4 M.				
161138 W CORONAE BOREALIS—								
	2781.6	9.8 Pt,	2781.8	9.8 Po,	2781.8	9.6 M,	2792.6	10.5 Y.
161607 W OPHIUCHI—								
	2753.3	12.5 Ym,	2756.6	12.3 L,	2766.7	12.0 L,	2781.8	11.0 Pt,
	2787.8	10.6 M.						
162112 V OPHIUCHI—								
	2791.8	9.0 Pt.						
162119 U HERCULIS—								
	2734.4	9.0 Ch,	2747.9	9.5 Ml,	2763.5	9.1 Gi,	2774.8	9.5 M,
	2775.9	9.5 Ml,	2781.7	9.7 Su,	2781.8	11.0 Pt.		
162807 SS HERCULIS—								
	2756.7	11.3 L,	2766.7	10.3 L,	2781.8	9.7 Pt,	2785.8	9.5 M.
163137 W HERCULIS—								
	2734.4	<11.0 Ch,	2750.5	<13.5 Ja,	2780.5	13.5 Ja,	2792.7	13.5 Y.
163172 R URSAE MINORIS—								
	2785.8	10.1 M.						
163266 R DRACONIS—								
	2735.4	10.0 Ch,	2763.8	12.0 M,	2778.8	<11.5 Bs,	2785.6	<12.0 Pi,
	2785.8	12.5 M,	2792.7	12.0 Y.				
164055 S DRACONIS—								
	2763.8	8.8 M,	2774.8	8.6 M.				
164715 S HERCULIS—								
	2763.5	7.8 Gi,	2763.8	7.8 M,	2785.8	8.2 M,	2786.8	7.5 Pt.
165030 RR SCORPII—								
	2775.9	7.4 Ml.						
165202 SS OPHIUCHI—								
	2781.8	12.3 Pt,	2782.8	<11.9 M.				
165631 RV HERCULIS—								
	2750.5	12.4 Ja,	2753.3	12.0 Ym,	2757.5	11.6 Ja,	2774.8	10.9 M,
	2777.5	11.0 Ja,	2781.8	11.7 Pt.	2785.8	10.8 M.		
170215 R OPHIUCHI—								
	2735.4	9.2 Ch.	2781.8	7.6 Pt,	2781.8	7.6 M.		
170627 RT HERCULIS—								
	2781.8	9.5 Pt,	2782.8	9.2 M.				
171401 Z OPHIUCHI—								
	2763.6	8.0 Gi,	2781.8	8.6 Pt.				
171723 RS HERCULIS—								
	2750.5	8.4 Ja,	2754.6	8.4 Ja,	2774.8	9.1 M,	2777.5	9.1 Ja,
	2781.8	9.0 Pt.						
172809 RU OPHIUCHI—								
	2781.8	11.6 Pt,	2785.8	11.4 M.				
174406 RS OPHIUCHI—								

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
	2783.8	11.2	Pt.									
175458a T DRACONIS—												
	2750.7	11.7	Gi,	2766.6	11.8	Gi,	2792.7	11.4	Y.			
175458b UY DRACONIS—												
	2792.7	11.7	Y.									
175519 RY HERCULIS—												
	2735.4	<11.7	Ch,	2786.8	13.7	Pt.						
180531 T HERCULIS—												
	2735.5	9.4	Ch,	2756.6	12.0	L,	2766.7	12.5	L,	2790.8	13.0	Pt.
180565 W DRACONIS—												
	2781.6	12.5	Pt.									
180911 NOVA OPHIUCHI #4—												
	2758.7	11.6	L,	2773.6	11.4	Gi,	2781.8	11.4	Pt,	2791.8	11.4	Pt.
181031 TV HERCULIS—												
	2756.6	10.3	L,	2766.7	10.9	L.						
181103 RY OPHIUCHI—												
	2763.6	10.5	Gi,	2781.8	8.5	Pt,	2782.8	8.3	M.			
181136 W LYRAE—												
	2750.7	11.1	L,	2764.7	12.1	L,	2781.8	12.4	M,	2786.8	12.2	Pt,
	2792.7	12.2	Y.									
182224 SV HERCULIS—												
	2750.7	10.8	L,	2764.7	11.5	L,	2781.8	12.3	Pt.			
182306 T SERPENTIS—												
	2781.8	10.0	Pt.									
183149 SV DRACONIS—												
	2792.7	12.3	Y.									
183225 RZ HERCULIS—												
	2781.8	9.8	Pt.									
183308 X OPHIUCHI—												
	2750.7	7.7	L,	2766.7	7.9	L,	2775.9	8.0	Ml,	2781.8	7.5	Pt,
	2782.8	7.8	M.									
184205 R SCUTI—												
	2735.5	5.9	Ch,	2750.7	5.0	L,	2753.3	5.0	Ym,	2756.7	5.2	L,
	2758.7	5.2	L,	2764.7	5.1	L,	2771.8	5.6	Pt,	2772.7	5.1	L,
	2778.3	5.9	Ym,	2780.7	5.6	L,	2781.8	5.3	Cd,	2781.8	5.6	Pt,
	2781.8	5.0	M,	2783.8	5.9	Pt,	2785.8	6.0	Pt,	2786.8	6.0	Pt,
	2790.8	6.1	Pt,	2791.8	6.3	Pt,	2792.8	6.6	Cd,	2797.9	7.0	Cd,
	2797.9	6.7	Pt.									
184300 NOVA AQUILAE #3—												
	2735.5	8.9	Ch,	2753.3	9.5	Ym,	2758.7	9.2	L,	2771.8	9.4	Pt,
	2778.3	9.1	Ym,	2780.6	9.2	Ja,	2781.8	9.0	M,	2781.8	9.1	Pt,
	2790.8	9.2	Pt.									
185634 Z LYRAE—												
	2785.8	<12.2	M.									
190108 R AQUILAE—												
	2781.8	11.5	Pt.									
190529a V LYRAE—												
	2791.8	10.0	Pt.									
190925 S LYRAE—												
	2759.8	11.3	L,	2764.7	12.0	L,	2782.8	12.1	Pt,	2782.8	11.5	M.
190926 X LYRAE—												
	2782.8	9.0	Pt.									
190933a RS LYRAE—												
	2785.8	11.4	Pt.									
190967 U DRACONIS—												
	2774.8	9.6	M.	2782.8	10.0	M,	2785.8	9.9	Pt.			
191019 R SAGITTARII—												
	2783.9	11.3	Pt.									
191033 RY SAGITTARII—												
	2764.7	5.8	L,	2782.8	6.6	Pt,	2783.8	6.3	Pt,	2785.8	6.5	Pt,
	2790.8	6.4	Pt,	2797.9	6.5	Pt.						

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
191350 TZ CYGNI—												
	2785.8	11.0	Pt.									
191637 U LYRAE—												
	2782.8	10.5	Pt,	2785.8	10.7	M.						
193449 R CYGNI—												
	2737.5	6.7	Ch,	2775.9	7.4	Ml,	2781.8	7.6	M,	2782.8	7.4	Pt.
193509 RV AQUILAE—												
	2782.8	10.4	Pt.									
193732 TT CYGNI—												
	2790.8	8.4	M.									
194048 RT CYGNI—												
	2737.5	7.5	Ch,	2766.6	9.2	Gi,	2781.8	10.6	M,	2782.8	10.5	Pt.
194348 TU CYGNI—												
	2781.8	10.4	M,	2782.8	10.3	Pt						
194604 X AQUILAE—												
	2781.8	9.1	M,	2782.8	9.7	Pt.						
194632 χ CYGNI—												
	2738.5<11.0	Ch,		2753.3<13.2	Ym,		2778.3	13.2	Ym,	2790.8	13.0	M.
195202 RR AQUILAE—												
	2785.8	10.0	Pt.									
195553 NOVA CYGNI #3—												
	2753.3	8.7	Ym,	2756.7	8.7	L,	2763.7	9.8	Mt,	2766.6	9.8	Gi,
	2766.7	8.9	L,	2767.6	10.0	Mt,	2771.8	9.4	Pt,	2777.7	9.4	Pt,
	2778.2	9.8	Ym,	2780.8	9.4	Pt,	2781.8	9.3	Pt,	2783.8	9.4	Pt,
	2785.8	9.5	Pt,	2786.8	9.4	Pt,	2790.8	9.4	Pt,	2791.8	9.6	M,
	2797.9	9.4	Pt.									
195849 Z CYGNI—												
	2750.7	10.6	Gi,	2766.6	11.6	Gi,	2781.8	11.8	M.	2782.8	12.3	Pt.
200212 SY AQUILAE—												
	2756.7	10.3	L,	2772.7	10.3	L,	2782.8	10.3	Pt.			
200357 S CYGNI—												
	2782.8	11.0	Pt,	2791.8	10.5	M.						
200715a S AQUILAE—												
	2750.7	9.0	Gi,	2766.7	9.1	Gi,	2781.8	10.7	M,	2782.8	11.0	Pt.
200715b RW AQUILAE—												
	2781.8	8.4	M.									
200906 Z AQUILAE—												
	2783.8	10.2	Pt.									
200916 R SAGITTAE—												
	2781.8	9.1	M.									
200938 RS CYGNI—												
	2738.5	8.7	Ch,	2758.7	8.1	L,	2781.8	8.8	M,	2782.8	8.6	Pt.
201008 R DELPHINI—												
	2758.7	11.9	L.									
201437 P CYGNI—												
	2737.5	4.8	Ch.									
201647 U CYGNI—												
	2753.7	7.9	Gi,	2766.7	8.0	Gi,	2781.8	7.7	M,	2782.8	8.1	Pt.
202539 RW CYGNI—												
	2781.8	9.0	M.									
202817 Z DELPHINI—												
	2786.8	11.3	Pt.									
202954 ST CYGNI—												
	2781.8	11.2	M,	2782.8	10.4	Pt,	2792.7	10.4	Y.			
203226 V VULPECULAE—												
	2782.8	8.5	Pt,	2782.8	9.0	M.						
203816 S DELPHINI—												
	2781.8	9.3	M.									
203847 V CYGNI—												
	2738.5<10.9	Ch,		2798.8	11.5	M.						
203905 Y AQUARII—												
	2798.8	11.5	M.									

VARIABLE STAR OBSERVATIONS, March 20 to April 20, 1921—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.	J.D.	Est.	Obs.
204016 T DELPHINI—												
	2781.8	11.0	M,	2783.8	11.9	Pt.						
204405 T AQUARII—												
	2783.8	7.9	Pt,	2798.8	8.1	M.						
204846 RZ CYGNI—												
	2798.8	<11.1	M.									
205030 UX CYGNI—												
	2798.8	11.7	M.									
205923 R VULPECULAE—												
	2753.7	7.6	Gi,	2783.8	8.8	Pt,	2785.8	9.0	M.			
210129 TW CYGNI—												
	2783.8	11.2	Pt.									
210868 T CEPHEI—												
	2719.0	7.9	Ch,	2754.4	6.5	L,	2766.3	6.3	L,	2782.8	5.8	M,
	2783.8	6.0	Pt,	2786.6	6.5	Cg.						
211614 X PEGASI—												
	2790.8	10.5	Pt.									
213244 W CYGNI—												
	2756.7	5.7	L,	2758.7	5.6	L,	2778.3	5.7	Ym,	2780.7	5.8	L.
213678 S CEPHEI—												
	2750.4	8.7	Gi,	2763.5	8.7	Gi,	2791.8	9.4	Pt,	2798.8	9.3	M.
213753 RU CYGNI—												
	2790.8	9.0	M.									
213843 SS CYGNI—												
	2717.0	8.5	Ch,	2718.0	8.4	Ch,	2720.0	8.4	Ch,	2725.0	8.7	Ch,
	2725.9	8.4	Jk,	2727.0	8.9	Ch,	2727.9	10.0	Jk,	2729.9	10.4	Jk,
	2730.0	10.0	Ch,	2750.3	11.8	L,	2753.3	12.0	Ym,	2756.7	11.9	L,
	2757.7	11.7	L,	2758.7	11.6	L,	2764.7	11.8	L,	2766.7	11.8	Gi,
	2766.7	11.9	L,	2771.8	11.9	Pt,	2772.7	11.5	L,	2773.6	11.8	Gi,
	2778.3	11.9	Ym,	2780.6	11.7	L,	2780.6	11.9	Ja,	2780.8	11.8	Pt,
	2781.8	12.0	M,	2781.8	11.7	Pt,	2782.8	11.8	Pt.	2782.8	12.0	M.
	2782.9	<11.3	Po,	2783.8	11.8	Pt,	2785.8	11.9	Pt.	2785.8	12.0	M.
	2786.8	11.8	Pt,	2787.8	12.0	M.	2790.8	11.6	M.	2790.8	11.9	Pt.
	2791.8	11.8	Pt,	2791.8	11.6	M,	2797.9	11.9	Pt.	2798.8	12.0	M.
213937 RV CYGNI—												
	2781.8	8.0	M.									
215934 RT PEGASI—												
	2790.8	10.8	Pt.									
222439 S LACERTAE—												
	2758.7	10.2	L.									
230759 V CASSIOPEIAE—												
	2754.3	12.2	Gi,	2766.3	12.1	Gi,	2785.8	11.5	Pt.			
231425 W PEGASI—												
	2764.7	9.0	L.									
233335 ST ANDROMEDAE—												
	2718.0	9.5	Ch,	2748.0	9.2	Ch,	2786.9	8.9	Pt.			
233815 R AQUARII—												
	2719.0	7.8	Ch.									
235053 RR CASSIOPEIAE—												
	2763.3	11.3	Gi.									
235855 Y CASSIOPEIAE—												
	2750.3	11.6	Gi.									

The Association is in a position to loan to one of its experienced members the 3-inch glass formerly owned and so successfully used by Mr. Lacchini. Applications for its loan will be gladly received by the Chairman of the Telescope Committee, Miss Annie J. Cannon, Harvard College Observatory, Cambridge 38, Mass. Through the generosity of several members the Association now possesses a printing outfit which greatly facilitates much of the work of the organization. The President takes this occasion to extend to the several contributors the thanks of the Association for making this outfit a reality.

Mr. Olcott, the Secretary, has just returned home and plans to erect a dome for his 5-inch glass on the roof of his house. Mr. D. B. Pickering has just secured an excellent 5-inch glass of very short focal length.

We welcome several new members this month, as follows:

Professor F. P. Leavenworth, Minneapolis, Minn.,
G. C. Olcott, Chicago, Ill.,
G. F. Townsend, Fort Worth, Texas.

A supplementary list of members elected during the past year has just been printed by our Patron, Mr. C. E. Barns, and distributed to all our members.

The following members contributed to this report: Messrs. Barns, "Bs," Bemporad, "Bp," Bouton, "B," Chandler, "Cd," Chandra, "Ch," Clement, "Cl," Miss Clough, "Cg," Dunham, "Du," Ginori, "Gi," Godfrey, "Gd," Miss M. Hall, "Hm," Miss Hawes, "Hs," Hodgkinson, "Hk," Janczewski, "Ja," Miss Jenkins, "Jk," Jordan, "Jd," Lacchini, "L," Lacy, "Lc," McAteer, "M," Menzel, "Mz," Merrill, "Ml," Merton, "Mt," Mundt, "Mu," Olcott, "O," Peltier, "Pt," de Perrot, "Pe," Pickering, "Pi," Potter, "Po," Reesinck, "Rk," Rhorer, "Ro," Suter, "Su," Watson, "Pw," Yalden, "Ya," Yamamoto, "Ym," and Miss Young, "Y."

Total Observations: 1,483. Stars Observed: 246. Observers: 35.

HOWARD O. EATON, Recording Secretary.

COMET AND ASTEROID NOTES.

Comet Dubiago.—A cablegram from M. Lecointe, at Uccle (Bruxelles), announces the discovery of a comet by Dubiago on April 29, and communicates the following elements, computed by the Bureau Petersbourg, and transmitted by Professors Kobold and Strömgren:

		ELEMENTS.
Time of perihelion passage	(T)	1921, May 7.61 G. M. T.
Perihelion minus node	(ω)	104° 45′
Longitude of node	(Ω)	66° 04′
Inclination	(i)	21° 42′
Perihelion distance	(q)	1.065

Harvard College Observatory Bulletin 752.
Cambridge, Mass., U. S. A., May 16, 1921.

Reid's Comet.—Attention is called to the photograph of this comet on page 293, of the May issue, the orientation of which is misleading. This is placed so that north is to the right, and east at the top.

Ephemeris of Reid's Comet.—The ephemeris below is of Reid's (1921 a) Comet based upon the parabolic elements of Dr. Crommelin on page 130 of the April 1921 number of the *Observatory*. The comet was nearest the earth about May 4.

1921 Gr. Mid.		α h	m	s	δ °	′	″	Log r	Log Δ
June	10	8	10	26	+51	33	32	0.05788	0.21134
"	14	8	12	30	+49	33	12	0.06984	0.23900
"	18	8	14	22	+47	47	20	0.08240	0.26400
"	22	8	16	6	+46	13	19	0.09536	0.28656
"	26	8	17	46	+44	49	2	0.10862	0.30693
"	30	8	19	22	+43	32	55	0.12200	0.32569
July	4	8	20	56	+42	23	43	0.13544	0.34180
"	8	8	22	28	+41	20	25	0.14886	0.35664

F. E. SEAGRAVE.

Winnecke's Comet.—A correction to the position of this comet given for April 17.6793, on page 292, of the May issue, has been made by Professor Frost through the H. C. O. Bulletin No. 751. The R. A. for this date should read 30^s19 instead of 28^s65.

An ephemeris of this comet extending through June is reprinted here from the H. C. O. Bulletin No. 753. This is based upon the following revised elements by Professor Crawford and Miss Levy.

ELEMENTS

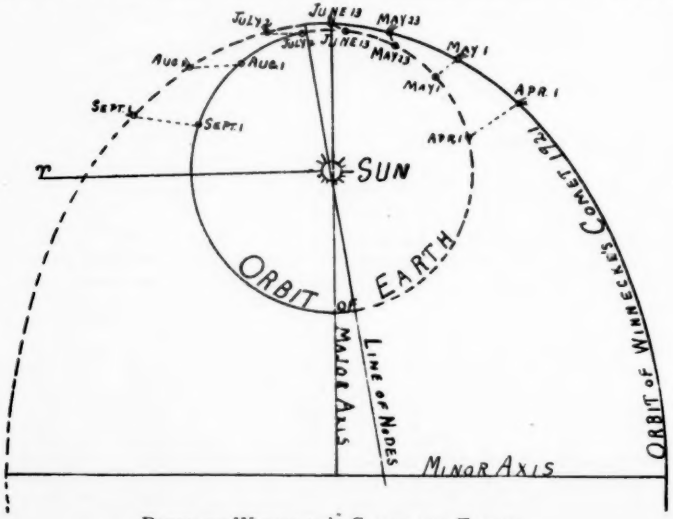
Time of perihelion passage	(T)	1921, June 12.95 G. M. T.
Perihelion minus node	(ω)	170° 34′
Longitude of node	(Ω)	97° 51′
Inclination	(i)	18° 50′
Perihelion distance	(q)	1.040
Eccentricity	(e)	0.6779
Periodic time	(P)	5.80 years (assumed).

EPHEMERIS

G. M. T. 1921	R. A. h m s	Dec. ° ′	Light.
June 2.5	20 38 58	+37 3.0	11.0
6.5	21 23 0	+30 15.5	
10.5	22 5 13	+21 31.4	14.4
14.5	22 43 27	+11 44.9	14.3
18.5	23 16 38	+ 2 11.6	
22.5	23 44 41	− 6 12.7	10.7
26.5	0 8 2	−13 8.6	
30.5	0 27 18	−18 42.6	6.7

The brightness on April 19 is assumed as 1.0.

The accompanying drawing, based upon the elements given above, shows the path of this comet as compared with the path of the earth for a few weeks before and a few weeks after the time of perihelion. The diagram does not take into account the inclination of the orbit, but since the inclination is not very large, and since perihelion occurs near the descending node the error is slight.



PATHS OF WINNECKE'S COMET AND EARTH.

In speaking of the likelihood of a shower of meteors as a result of the approach of this comet, Professor Crommelin in "The Observatory" for May says:

"The descending node lies almost exactly on the Earth's orbit. The comet passes it on June 16, the Earth on June 25. There is thus an excellent prospect of a meteor shower on the latter date. If the above position of the node is exact, the Earth will pass it about $4^h\ 30^m$ P.M., (G.M.T.), so that the shower may occur in daylight in Europe and America. It is to be hoped that observers in India, and elsewhere in Asia, will be on the alert. The least distance from the Earth (June 7) is 12 1/3 million miles; this is a smaller distance than that of Eros at its nearest, and the horizontal parallax will be 66″."

Ephemeris of the Asteroid (24) Themis.—The following ephemeris was computed with the aid of the tables given in the Copenhagen Observatory Publication No. 36.

1921 Gr. Mid.		R. A. h m s	Dec. ° ′	Log Δ
June	27	19 8 4	—23 34.0	0.3870
July	1	4 47	39.4	
	5	19 1 27	44.6	0.3863
	9	18 58 6	49.4	
	13	54 49	53.9	0.3887
	17	51 37	23 58.0	
	21	48 33	24 1.5	0.3944
	25	45 41	4.4	
	29	43 1	6.8	0.4029
August	2	40 37	8.7	
	6	38 30	10.1	0.4140
	10	36 41	11.1	
	14	35 11	11.6	0.4271
	18	34 1	11.8	
	22	33 12	11.6	0.4417
	26	32 43	11.2	
	30	18 32 34	—24 10.4	0.4574

Opposition 1921 July 6. Magnitude 11.3.

JULIE M. VINTER HANSEN.

Copenhagen, University Observatory, 1921 Febr. 13.

Asteroid (433), Eros.—Herewith I am sending you constants and an ephemeris for the opposition of 1921 of the asteroid Eros, which will take place on September 6. All of these figures are based upon the latest elements from *Bahnelemente Der Kleinen Planeten 1920.*

CONSTANTS.

$$x = r\,[9.99464]\ \sin\,(\ 34^\circ\ 16'\ 49''.94 + u)$$
$$y = r\,[9.94129]\ \sin\,(299^\circ\ 13'\ 42''.30 + u)$$
$$z = r\,[9.70854]\ \sin\,(319^\circ\ 41'\ 37''.84 + u)$$

EPHEMERIS.

1921 G. M. T.		α h m s	δ ° ′ ″	Log r	Log Δ
July	23.5	23 41 46	+ 7 0 13	0.23754	9.98409
"	27.5	23 41 45	+ 7 52 45	0.23600	9.96672
"	31.5	23 41 4	+ 8 43 52	0.23438	9.94938
Aug.	4.5	23 39 39	+ 9 33 14	0.23266	9.93211
"	8.5	23 37 28	+10 20 10.90	0.23088	9.91512
"	12.5	23 34 30	+11 4 12	0.22900	9.89861
"	16.5	23 30 44	+11 45 7	0.22700	9.88265
"	20.5	23 26 11	+12 21 52	0.22494	9.86759

1921 G. M. T.		α h	m	s	δ °	′	″	Log *r*	Log Δ
Aug.	24.5	23	20	50	+12	53	57	0.22278	9.85358
"	28.5	23	14	47	+13	20	8.60	0.22056	9.84098
Sept.	1.5	23	8	7	+13	37	55	0.21826	9.83001
"	5.5	23	0	57	+13	53	31	0.21586	9.82082
"	9.5	22	53	30	+13	59	57	0.21338	9.81369
"	13.5	22	45	56	+13	59	23	0.21080	9.80859
"	17.5	22	38	28	+13	52	19	0.20812	9.80567
"	21.5	22	31	18	+13	39	3	0.20538	9.80499
"	25.5	22	24	37	+13	20	53	0.20258	9.80636
"	29.5	22	18	34	+12	58	31	0.19964	9.80960
Oct.	3.5	22	13	19	+12	33	15	0.19664	9.81463
"	7.5	22	8	58	+12	6	33	0.19356	9.82109
"	11.5	22	5	33	+11	39	15	0.19038	9.82883
"	15.5	22	3	7	+11	12	38	0.18714	9.83753
"	19.5	22	1	38	+10	47	20	0.18378	9.84689
"	23.5	22	1	8	+10	24	28	0.18038	9.85684
"	27.5	22	1	31	+10	3	54	0.17688	9.86713
"	31.5	22	2	50	+ 9	46	48	0.17332	9.87757
Nov.	4.5	22	4	56	+ 9	32	28	0.16966	9.88808
"	8.5	22	7	51	+ 9	21	58	0.16596	9.89850
"	12.5	22	11	29	+ 9	15	20.50	0.16218	9.90872
"	16.5	22	15	49	+ 9	12	25	0.15834	9.91868

F. E. SEAGRAVE.

Boston, January 29, 1921.

COMMUNICATIONS.

Magnifying Power of an Eyepiece.—I wish to call your attention to a simple and yet fairly accurate method of finding the magnifying power of an eyepiece for one who has access to the use of a theodolite. It has probably been used before and may be a common practice, but I have never heard or read about it.

A distant object, having two conspicuous points in a horizontal line, is sighted through the telescope with both eyes open. By partly closing the eye which receives the most light and slightly shifting the head, it is always possible to bring the two points in the image to coincide with two conspicuous points or vertical lines as seen with the naked eye. The telescope is then removed and the theodolite set up in its place or as near to the pier as convenient, if the mounting is fixed, and it is used to measure the angle between the two points in the distant object and the angle between the corresponding points as seen with the naked eye. The ratio between the two angles is the required magnifying power.

D. F. BROCCHI.

Seattle, May 8, 1921.

"Latitude Without Instruments" by Russell W. Porter in your current issue, recalled a somewhat similar experiment I made some ten years ago, June 22, 1911, from a window of the drafting room of the Steam Engineering Division of the Brooklyn Navy Yard, where I was stationed at the time. It is generally known that the Ancients approximated their latitude by the gnomon, and it is quite likely that the obelisk at Central Park, N. Y., and a similar one on the Thames Embankment, London, were erected for this and other astronomical purposes. In lieu of an obelisk I used a draftsman's triangle, the perpendicular side of which was 8¾ inches. The sill of the window being level, it was

only necessary to place it in the meridian plane and measure the projected shadows cast upon it at noon, when the siren blew, and as this happened within a couple of minutes of the sun being on the meridian at the summer solstice, the equation of time was disregarded. The sun being 23° 27′ 9″.67 North, it only remained to find the shadow angle. Dividing the length of the shadow, 2¾ inches plus, by the perpendicular heighth 8¾ inches of the triangle resulted in furnishing the natural tangent of the angle which corresponds to an angle of about 17° 29′. In order to correct for the penumbra shadow cast by the limb of the sun its semidiameter 15′.46 was subtracted making the angle 17° 13′.54. An arithmetical mean of the lengths of the penumbra and the true shadow would have given a similar result, no doubt, but it did not occur to me at the time. Another correction was made of 1′.02 for refraction, giving the zenith angle of 17° 14′.56 and adding this to the sun's declination, resulting in the latitude of 40° 41′ 42″.6 which was within a few seconds of arc of being correct.

Bearing in mind that physical shadows are not as sharply defined as the accuracy of the problem would require, nevertheless, it will afford the amateur astronomer, navigator and students interested, an opportunity to brush up on their physics, geometry and trigonometry.

EDWARD A. OSSE,
Instructor in Charge, Apprentice School,
U. S. Naval Ordnance Plant,
So. Charleston, W. Va.

GENERAL NOTES.

The next issue of POPULAR ASTRONOMY, the August-September number, will be mailed about August 1.

Professor Ernest W. Brown, of Yale University, has been elected a correspondent of the French Academy of Science.—(*Science,* April 29, 1921.)

Professor A. S. Eddington has been elected president of the Royal Astronomical Society.—(*Monthly Notices,* February 1921.)

Professor A. A. Michelson, of the University of Chicago, has been awarded the Albert medal of the Royal Society of Arts for his discovery of a natural constant which has provided a basis for a standard of length. Professor Michelson has also recently received from the Sorbonne the honorary degree of Doctor of Science.—(*Bulletin of the Am. Math. Soc.,* May, 1921.)

Dr. Warren K. Green, instructor in Physics at Yale University, has been appointed to the faculty of Amherst College and is to have charge of the Amherst Observatory with its 18-inch telescope. Dr. Green received the Ph. D. in Astronomy at the University of California in 1917.

Miss Mary Murray Hopkins, who for a number of years has been connected with the work of astronomy at Smith College, died at her home in Northampton on May 18, after an illness of one week.

Mrs. Edward E. Barnard.—It is with very deep regret that we record the death of Mrs. Edward E. Barnard which occurred on May 25 after an illness of nine days following a stroke of apoplexy. Simple funeral services were held at the home in Williams Bay, Wisconsin, on May 26. The body was taken to Nashville, Tennessee, for interment.

The American Philosophical Society has recently elected fifteen men from various parts of the United States to membership. Among those elected is Dr. V. M. Slipher, Director of the Lowell Observatory, Flagstaff, Arizona.

Astronomy in the Harvard Summer School.—Dr. H. T. Stetson announces that a course in Descriptive Astronomy will be given in connection with the Summer School at Harvard University, July 5-August 13. Special emphasis will be placed on laboratory methods of demonstration and instruction. Daytime lectures will be supplemented by evening exercises for constellation study and observations with the telescope.

Unusual Aurora Phenomena.—On the night of May 14 and the following night May 15, very brilliant and unusually striking aurorae were observed in this locality (Northfield, Minn.). Even in the moonlight the sky assumed a great variety of color and brightness. The streamers were very noticeable from all points of the horizon, meeting at the zenith. The following notes show that the display was visible throughout a large territory, practically the entire United States.

Aurora Visible in Seattle.—Mr. D. F. Brocchi of Seattle, Washington, writes the following description of the aurora there on May 13:

As the aurora rose in the sky and the shafts became more frequent and conspicuous, it grew in intensity and separated in three sections, the upper one an even and bright band 4° or 5° wide and extending to within 10° or 15° of the horizon at both ends. It did not begin to fade until it had reached nearly to the zenith, and was well beyond it when it slowly vanished. The second section extended from about the magnetic north toward the east about 30°, rose only slightly and soon partly vanished and partly merged into the main arch. This became more brilliant and concentrated into a very beautiful narrow band with many narrow shafts extending downward. It broadened again and became paler, while bright shafts 10° wide and more and extending to the zenith and beyond, would play in rapid succession, the largest of them richly tinted with violet, while the dominant color of the display was a pale green tending toward the blue.

The Aurora of May 14, 1921.—8 P. M. (Central Standard Time).—A fine auroral glow was conspicuous in the northern sky at Indianapolis, Indiana. In the course of half an hour, it passed Arcturus and Spica and extended as far south as Corvus and Crater.

9 P. M.—There was a brilliant, greenish light in the southeast and the auroral haze had drifted as a unit into the southern sky, giving the impression of moonrise in that quarter of the heavens and leaving the northern sky entirely dark.

9:25 P. M.—In the north, short vertical rays were projected on an invisible,

sinuous line about the altitude of Polaris, and in the northeast, brilliant green streamers tipped with red were directed toward a point a little south of the zenith where converging beams from the north, east and west formed a corona about 10° west of Arcturus. Beams from the south were absent, but the southern sky was illuminated by a brilliant bank of apple green light. Delicate pink hues played gently over the semi-dark region of the corona. At the height of the display the moon itself (first quarter May 14) was dimmed and the stars of the Big Dipper were faintly visible. Large areas of red light appeared in the south, southwest and near the moon. The whole sky was ablaze with auroral light which later extended to the northern horizon where black stratus clouds were silhouetted against it.

10 P. M.—The corona was renewed and by 11 P. M. a fine corona was formed 5° east of Arcturus by converging beams from the east (beams from other quarters of the sky were absent) giving the appearance of a comet with a tail 40° long; at 11:45 P. M. a complete corona formed about 15° east of Arcturus.

From 11:45 to 12 midnight greenish lights appeared in the northwest and drifted into the southern sky where they dropped short bundles of bright green rays close to the southern horizon. Although lights were still conspicuous in the sky at 1:30 a. m., May 15, cirro-cumulus clouds interfered somewhat with the later phases of the display.

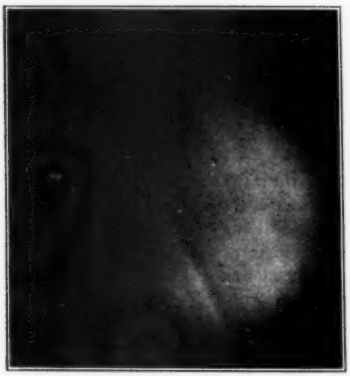
RUSSELL SULLIVAN.

Indianapolis, Indiana.

Photographs of Aurora at Lowell Observatory.—Mr. O. H. Truman writes as follows concerning his success in photographing the aurora visible at the Lowell Observatory:

"I am inclosing three pictures of the great aurora of the night of Saturday, May 14, which may be of interest to you, though you are doubtless receiving many others.

No. 1



No. 2

"They were made on Seed 30 plates, with a Voigtlander portrait lens of 3-inch aperture and 6.75-inch focus. The contrast has been much increased, in order to get suitable reproductions on paper, and they have been enlargel 1.31 times.

No. 3

"Nos. 1 and 2 were in the northwest, only a minute or two apart; No. 3 was exposed by Mr. G. H. Hamilton, in the northeast. All were perhaps 10° to 20° above the horizon. Exposure for No. 1 and No. 2, 40 seconds; for No. 3, about 20 seconds.

"These pictures, aside from so well bringing out the streamers, are of interest as showing the effectiveness of photography with one of these fast lenses. The streamers shown in No. 1 and No. 2 were very faint, as the greatest vigor of the aurora had passed; indeed these pictures were only made for luck, as there seemed no hope of getting much on them. Had I known how effective the lens would prove to be, I would have made many others."

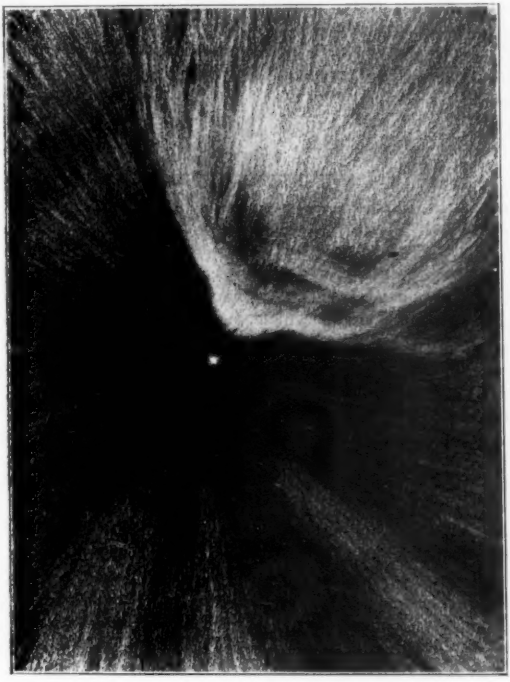
O. H. TRUMAN.

Lowell Observatory, Flagstaff, Ariz., May 23, 1921.

An Unusual Development of an Aurora.—At 9^h 35^m, Eastern Standard Time, while in Riverside Drive, New York City, I noticed an unusual illumination of the sky in the south, slightly east. At first I thought it a haze cloud in the light of the moon whose phase was that of the first quarter, the date being May 14. The sky was clear and there was little haze in the atmosphere near the horizon and none at all in the zenith. The north was clear of any evidence of an aurora as far as I could see, which was down to within about ten degrees of the horizon. The luminous cloud in the south reached as far as about thirty degrees above the horizon. If it had been in the north I would have at once pronounced it an aurora because it gradually increased in brightness and was greenish white.

At about ten thirty there suddenly appeared in the southeast a long auroral streamer pointing almost precisely toward the star Arcturus and approaching it to within about five degrees. Instantly other streamers began to appear farther toward the east extending toward the same apex. In a few minutes I noticed what seemed to be big fluffy white clouds in a circle of about thirty degrees diameter around Arcturus and that portion of the circle in the northwest began to drift toward the star with swift motion. As it entered the dark opening around the star it assumed the most remarkable aspect, one which I have never before

seen in an aurora. The forward part of the cloud seemed to be caught in a current of air and bulged out like a puff of smoke leisurely blown from a cigarette. Indeed this portion of the luminous mass appeared to be an exceedingly diaphanous cloud separated in striae which became iridescent with striking and



A Shining Auroral Cloud Moving Toward Arcturus from the Northwest. The Cloud Showed Colors of Pale Green and Lavender.

beautiful colors, peacock green and lavender being the most conspicuous. The dense mass of luminosity in the south varied from orange to crimson while the region around Arcturus became so bright that had there been no moon it would have cast a glow on the ground brighter than that of the light from the half-moon. It was certainly brighter than would have been the light of the zenith moon in its half phase as observed shining on an ordinary cloud, if such a position had been possible for the earth's satellite at this time.

The aurora quickly reached the stage of the corona with Arcturus almost exactly in the center of the crown, its displacement could be gauged by the angular distance of the star from the zenith of New York City. The effect was one of continuous change and the whole show while at its best lasted only about six or seven minutes. The pulsations producing the effect of draperies waving in a wind were brief but very conspicuous. At one time it seemed that the "draperies," auroral streamers and iridescent needles as well as the luminous clouds were

working their hardest simultaneously. The general effect was that of masses of bright material coming up from all directions and closing in around the dark space surrounding Arcturus, the clouds and needles of light vanishing as they reached this dark apex of the crown. None of the auroral phenomena seemed to be visible below the Great Dipper, though at times the stars of the Dipper were completely hidden by the brilliance of the clouds. This is the first time I have ever seen an aurora develop from the south. The extreme lower rim of the irregular clouds across the west and north was bordered by a rainbow-like band with green above and red below, producing an effect of diffraction as in a solar corona.

LATIMER J. WILSON.

New York City, May 15, 1921.

Sunspots and Aurora Observed.—In connection with the widespread prevalence of the aurora during Saturday and Sunday, May 14 and 15, as reported in the daily press and which was also observed at this station both nights, I made an interesting observation with my grating spectroscope attached to the 5½" refractor on Sunday afternoon. I had just finished my usual sunspot observations delineating the group which was just past the central meridian and which had assumed the large two spot formation and appeared to be in an active condition when about 2:30 P. M. I attached the spectroscope and soon discovered that the C and F lines were very brilliantly reversed over the umbra of the preceding or west spot of the group, the brilliancy was not constant, seeming to vary from time to time and distorted towards the red end of the spectrum. I did not notice any marked effect on the helium line, the D lines were much widened. I observed until about 3 P. M. when I was called away and could not again observe until 4:30 at which time the disturbance had almost entirely ceased, only the merest trace of slight reversals being seen, observations continued until after 5 P. M. and the sun was getting a little too low for further work. The auroral display here early Sunday morning was exceptionally fine, streamers and beams with colored effects being noted in every direction. The local telephone station had considerable difficulty in keeping the drop numbers in place all night.

DAVID E. HADDEN.

Alta, Iowa, May 17, 1921.

Wanderlust.

The Midway lights shine soft tonight,
  The chimes ring clear through twilight air;
The slim moon hangs o'er Harper's towers—
  Why do you leave a town so fair?

Close to the moon, and near as bright
  Fair Venus flaunts her charms at Mars,
And all the history of the world
  Is written in these gleaming stars.

Why is it you think naught of these,
  But watch them with unseeing eyes,
And leave the beauties close at hand
  To seek Romance 'neath distant skies?

Chicago Tribune, "Lineotype." —LUCY.